STUDSVIK,
U.S. NUCLEAR BOMBS,
AND
U.S. NUCLEAR WASTE

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Introduction

Spent fuel from the R-2 research reactor at Studsvik Energiteknik AB is sent to the United States where it becomes raw material for nuclear weapons. The spent fuel contributes to the U.S. supply of plutonium, high enriched uranium (HEU), uranium-238, and tritium. A modern nuclear bomb contains all these materials. A diagram illustrating the different components of an H-bomb is represented in Figure 1.

The Studsvik spent fuel, highly enriched in uranium-235, has been sent to the reprocessing ("upparbetning") plant and plutonium production reactors at the Savannah River Plant (SRP) in South Carolina, and the Idaho National Engineering Laboratory (INEL) reprocessing plant in Idaho Falls, Idaho.[1] Both SRP and INEL are key facilities in the U.S. nuclear weapons production complex, as is illustrated in Figure 2. Both are run by the U.S. Department of Energy (DOE), which enjoys the privilege of regulating its own activities.

There are five military production reactors at SRP, which were the only U.S. domestic source of tritium and weapons grade plutonium. Two of the five reactors are shut down permanently, and the remaining three reactors were shut down in April 1988 because of dangerously old equipment and incompetence of plant operators. These three were cut back to 40% capacity from after the Chernobyl accident to the time of their shutdown. A few of the reactors may restart in 1990. To insure supplies of tritium, the DOE plans to build two new tritium producing reactors, one at SRP and the other at INEL at a cost of about US $7 billion over the 10 year construction period.

At both the SRP and INEL there have been huge releases of radioactive gas to the atmosphere and liquid waste into the ground, putting at risk the health of thousands of workers and millions of people living downwind and downstream. The long-lived nature of the radioactivity also endangers future generations. Further, since SRP and INEL are only two links in a complex chain of facilities located throughout the U.S., dangerous radioactive materials are continually moved between links in the chain.

Below is some brief information about the Studsvik R-2 reactor. Then, a summary of the Studsvik - U.S. DOE trade agreement, and public trade statistics are given. Included is an example of a formal license document given to Studsvik to export spent fuel. Before a short conclusion and list of some questions raised, some additional facts about problems at SRP are added.

A "Glossary of Technical Terms" is included at the end for readers unfamiliar with definitions of low and high enriched uranium, plutonium, reprocessing, and tritium.

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[1] The reprocessing plant at INEL is called the Idaho Chemical Processing Plant.

The Studsvik R-2 Reactor

Studsvik operates two non-electricity producing research reactors called R-2 and R-2-0. They are fueled with HEU. J, Dexter Peach, Director of the Resources, Community, and Economic Division of the United States General Accounting Office, wrote in a 1984 investigation,

> *"Research reactor spent fuel, like commercial reactor spent fuel, is considered highly radioactive and can be lethal..."*[2]

Fresh fuel for the R-2 reactor contains 93% uranium-235. Spent fuel from the R-2 reactor is about 70% enriched. The 20% difference is made up of plutonium and other fission products.

This is how a Studsvik brochure describes the R-2 reactor:

> *"Since the 1960's our 50 MW reactor R-2 has been used for fuel testing, materials testing, neutron transmutation doping of silicon, neutron activation analysis, radionuclide production and basic research...."*
>
> *"In 1985, after nearly 25 years of operation, the R-2 reactor was equipped with a new reactor vessel and a modified core. The R-2 reactor now offers a larger variety of test conditions, and will ensure the availability of neutron irradiation capacity for fuel testing and other purposes well into the future."*[3]

The R-2-0 research reactor is much smaller, rated at only 1 MW. It also began operation in 1960.[4]

The Studsvik - U.S. DOE Trade Agreement

In the mid-1950's, the United States began exporting HEU for use in foreign research reactors. Only countries that entered into formal international agreements for nuclear cooperation with the U.S. can receive HEU. The agreements are designed to assure the U.S. that the HEU will be used for authorized purposes only, will be properly safeguarded and will not be retransferred except as allowed by the agreement.

It is an option of the receiving country to decide if the spent fuel is sent to the U.S. for reprocessing and final storage. The agreement may allow the spent fuel to be sent to a third country. The United States signed nuclear cooperation agreements with

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[2] Peach, J, Dexter, Director of the Resources, Community, and Economic Division, United States General Accounting Office. December 13, 1984. "Letter to The Honorable Richard L. Ottinger, Chairman, Subcommittee on Energy Conservation and Power, Committee on Energy and Commerce, House of Representatives." US GAO B-217124. 12 pp. United States General Accounting Office, Washington, D.C., U.S.A. 20548. See p. 8.

[3] Studsvik Nuclear. Undated (late 1980's). "Studsvik Nuclear." 8 pp. Studsvik AB, S-611 82 Nyköping, Sweden. Tel. 46-155-210 000. Fax: 46-155-630 00. See pp. 2 and 3.

[4] Nuclear Engineering International. 1988. "World Nuclear Industry Handbook." 358 pp. Orders: Computer Posting, 120-126 Lavender Avenue, Mitcham, Surrey, U.K. CR4 3HP. See p. 154.

43 countries between 1954 and mid-1984, and had exported about 16,700 kilograms of HEU.[5] Of these 43 countries, 14 are reported to have returned the spent research fuel, totalling about 1,500 kilkograms.[6]

In the Studsvik-DOE trade agreement, 93% HEU fuel has been purchased from the U.S. for the R-2 reactor, and the spent fuel has been sent to the United States. Before arriving in Sweden, the fresh U.S. HEU has been put into fuel elements in France by CERCA and in West Germany by NUKEM.[7]

When spent fuel is sent to the U.S., DOE requires that a contract be signed. The contract specifies that the country sending the fuel is responsible for transport of the fuel to a DOE reprocessing facility and to pay the cost of reprocessing and waste storage. The sending country is given a credit, equal to the value of the uranium extracted during reprocessing, on their next purchase of HEU.[8]

The Studsvik spent fuel is transported in a metal form in specially designed casks. The U.S. NRC licensed two companies to handle transport of the spent fuel: Transnuclear and Edlow International.[9] The U.S. Coast Guard inspects the spent fuel casks upon arrival at a U.S. port, and the DOE inspects them at their destination, which is either INEL or SRP. At both sites, the unused enriched uranium was extracted in reprocessing plants. At the SRP there is also a reprocessing plant capable of extracting plutonium-239.

Prior to 1982, most of the spent fuel returned to the U.S. was shipped to the SRP for reprocessing. Beginning in 1982, most was shipped to INEL, which has the capability to extract krypton. At that time there was a shortage of krypton in the U.S.

After reprocessing, the recovered uranium is sent to Oak Ridge, Tennessee where it is mixed with similar material and converted into a metal form. The metal was then shipped to the SRP where it was made into nuclear fuel. This fuel, called driver fuel, was used in the SRP reactors to produce plutonium-239 and tritium. According to a DOE official the only use of the driver fuel produced from previously burned HEU fuels was in the Savannah River Plant's reactors.[10]

Studsvik - U.S. DOE Trade Statistics

According to the U.S. General Accounting Office, the uranium extracted from all foreign research reactor spent fuel was less than one percent of the total used in the

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[5] Op. Cit. Peach, J, Dexter. See p. 3.

[6] Op. Cit. Peach, J, Dexter. See p. 4. The 14 countries are: Austria, Belgium, Canada, France, Italy, Japan, Mexico, Netherlands, South Africa, Sweden, Switzerland, United Kingdom, and West Germany.

[7] SKI. March 31, 1988. "Redovisning av genomförda transporter av kärnämna och kärnavfall till och från Sverige under åren 1980-1987." 34 pp. SKI, Box 27106, S-102 52 Stockholm. Tel. 08-663 55 60. The report can be ordered at no cost from Cathrine Johansson, Byrådirektör Informationsenheten, SKI. See p. 18.

[8] Op. Cit. Peach, J, Dexter. See p. 3.

[9] Op. Cit. Peach, J, Dexter. See p. 5.

[10] Op. Cit. Peach, J, Dexter. See p. 9.

driver fuel, of which the Swedish contribution was about 12 percent.[11] Thus, the Swedish contribution to the total uranium in all the driver fuel is not more than two hundredths of a percent.[12] Another way of expressing this would be to say that for every 10,000 nuclear bombs produced in the U.S., one or two were made with driver fuel containing highly enriched uranium from the Studsvik R-2 reactor. Further, in order to quantify the total contribution of the Studsvik spent fuel to U.S. nuclear weapons, the tritium and plutonium extracted and produced ought to be considered. The size of the U.S. nuclear arsenal is maintained at about 25,000 warheads, and about 4,000 new nuclear bombs are produced or modified each year.[13] With an inventory of that size, the Swedish contribution has certainly been several bombs.

Table 1 lists the exports of spent research reactor fuel from Studsvik to SRP and INEL that are public. According to this data a total of about 211.5 kg of spent fuel was exported up to 1986. If on the average this fuel contained 70% uranium-235, these 211.5 kg would contain about 148.1 kg uranium-235.

Table 1
Exports From Studsvik to SRP and INEL By Year [14]

	Total kg	% U235
1980: 3.3 + 3.6 + 3.574 + 2.931 + 6.7=	(20.105)	64.9 - 73.1
1981: 7 + 6.4=	(13.4)	68. - 72.
Total prior to 1982	153.8	
1982: 6.9 + 6.7=	13.6	71. - 73.
1983: 6.1 + 6.5=	12.6	68. - 72.
1984: 6.6 + 6.6=	13.2	72.
1985:		
1986: 9.3 + 9.=	18.3	73. - 75%
Total	211.5	

Certifikat nr S/23/B(M)F (rev 4) (20/85)

SKI "Certifikat nr S/23/B(M)F (rev 4) (20/85)" issued 10 October 1985 is an example of the formal license document ("certifikaten") given to Studsvik to export spent fuel. This particular license is not listed in the 31 March 1988 report by SKI of shipments of radioactive materials to and from Sweden between 1980-1987. It is possible that the license was lumped together with another one later on. Though, if that is the case, the competence of SKI is in question.

The license, included as Appendix 1, gives permission to Studsvik to send 48

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[11] Op. Cit. Peach, J, Dexter. See pp. 3 and 4. This document reports that up until December 1983 a total of 1496.5 kg of HEU were returned to the U.S. from research reactors, including 179.9 kg from Sweden; 179.9 is about 12% of 1496.5.

[12] 12% of 1% equals 0.012%.

[13] Op. Cit. Radioactive Waste Campaign. See p. 19.

[14] This data is taken from two sources: (1) Op. Cit. SKI. March 31, 1988. See pp. 17-18, and Tables 1 and 2 (where license numbers are included). (2) Op. Cit. Peach, J, Dexter. See p. 4. The only additional information contained in reference (2) is the total for prior to 1982. Reference (1) does not contain any data prior to 1980.

Material Test Reactor (MTR) fuel elements to the U.S. Department of Energy's Savannah River Plant. It documents that the 48 fuel elements contain 6.612 kilograms of uranium, of which 4.821 kilograms are uranium-235. Thus, the fuel elements contain 72.9% HEU.

The Savannah River Plant

This key facility was projected to take up about 20% of DOE's 8.1 billion dollar weapons production budget for 1989. About 11,000 people work at the 300 square-mile site. Among the facilities at SRP are two reprocessing plants and five now closed military production reactors. One of the reprocessing plants is constructed to only extract tritium. The other plant is constructed to extract plutonium and uranium.

A Congressional hearing in fall 1988 turned up scandal after scandal at SRP. DOE admitted that dozens of unreported accidents have taken place at SRP, and that if the SRP had been a civilian plant it would have been closed down. SRP has grossly contaminated the Savannah River, into which the plant effluent si dumped. When fuel failures occurred, the reactors were simply flushed out and the water dumped in the river. A distance of 7.5 km downstream from the site is described as "very hot" by a SRP official.[15]

Seepage basins that contain the waste water from the plutonium production process have also been a source of contamination. The basins are huge ponds, with no liner on the bottom. Contamination seeps directly into the groundwater through the soil. About 4.5 million liters per day of radioactive liquids have been estimated to seep through each of the 68 basins, totaling over 2000 billion liters for a 20 year operating life.[16] No-one knows where the radioactive liquids have gone.[17] Critics of SRP are worried that contamination will reach the huge underground Tucaloosa aquifer that supplies drinking water to South Carolina and several other states. At INEL, until the mid-1980's, liquid waste was even disposed of via injection wells into aquifers.[18]

Significant contamination is documented on the surface of the soil throughout the 300 square miles of the SRP. Tritium is found in pine needles over 150 km downwind. However, DOE will not make public how much of what toxic material has been dumped where. It is known though, that some plutonium-contaminated wastes were buried in cardboard boxes. The cardboard collapsed, allowed soil above to subside and extra water leakage into the site.[19] DOE estimates it could cost as much as $7 billion to clean up the SRP site.[20]

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[15] This information is taken from interviews of SRP staff published in: del Tredici, Robert. 1987. "At Work In The Fields Of The Bomb." 192 pp. See pp. 141-144.
[16] Op. Cit. del Tredici, Robert.
[17] Op. Cit. Radioactive Waste Campaign. See p.7.
[18] Radioactive Waste Campaign. 1988. "Deadly Defense". 169 pp. Radioactive Waste Campaign, 625 Broadway, 2nd Floor, New York, New York, U.S.A. 10012. ISBN: 0-9619078-2-7. See p. 29.
[19] Op. Cit. del Tredici, Robert.
[20] Beck, Melinda, and Waller, Douglas. March 14, 1988. "The Plutonium Factor". One page. Newsweek, March 14, 1988, page 67.

Conclusion And Questions Raised

No matter how small the Swedish contributions are to the U.S. nuclear weapons program and to the health and environmental problems at SRP and INEL, that there is a contribution can not be denied. It can be argued that the only number of nuclear bombs that is insignificant is zero. Further, the mere existence of the trade is inconsistent with the Swedish policy of storing its own nuclear waste, and represents a double moral on the part of Sweden: a practice that is illegal in Sweden is allowed in the U.S. with Swedish contribution.

Whatismore, the trade in HEU between Sweden and the U.S. clearly points out that Sweden is NOT a neutral country. However small, the trade represents a direct Swedish connection to the U.S. nuclear weapons industry.

The information presented raises a number of questions, including:

- What has happened to all the Studsvik spent fuel right from initial start-up of the Studsvik reactors to the present (the SKI and US GAO reports noted above are not comprehensive)?
- What is happening to the Studsvik spent fuel now that the SRP plutonium production reactors are closed down?
- What are the total quantities of plutonium, uranium-235 and -238, and fission products that have been separated from the Studsvik spent fuel?
- How much HEU was contained in the driver fuel at the SRP plutonium production reactors?
- How much plutonium, uranium-235 and -238 are needed for different types of nuclear bombs?
- Are the formal international agreement for nuclear cooperation between the U.S. and Sweden, and the reprocessing contract public documents?
- What are the economic obligations in the international agreement and reprocessing contract?
- Can copies be received of the U.S. Coast Guard and DOE cask inspections?
- Do the CERCA and NUKEM fuel fabrication plants have military connections?
- What alternatives are there to sending the Studsvik spent fuel to the U.S.?

* * * *

Glossary of Technical Terms

low and high-enriched uranium:

In its natural state, uranium is more than 99% uranium-238, .7% uranium-235 and less than .01% uranium-234. The primary purpose of the uranium processing (mining, milling, refining, enriching, and reprocessing) is to extract the uranium-235 for use in nuclear weapons and reactors. The uranium-235 is sought after because it is a fissile material. Uranium enters an enrichment facility containing .7% uranium-235; almost all the remaining part is uranium-238. The final product may contain anywhere from 3 to more than 90% uranium-235. This product is called "enriched uranium", as its quantity of uranium-235 is increased. The material remaining is called "depleted uranium" because most of the uranium-235 is taken out. Depleted uranium (DU) is almost pure uranium-238.

The most important use of DU is as a material for transformation to weapons grade plutonium in a nuclear reactor. DU can not by itself cause an atomic explosion, and is abundant because it is a by-product of the enrichment process. It is used as: a counter-weight in jumbo-jets and ships: armour piercing, incendiary ammunition; and as part of the explosive component in nuclear weapons.

If the proportion of uranium-235 is low, such as the about 3% level used in commercial nuclear power reactors, it is referred to as low-enriched uranium (LEU). High-enriched uranium (HEU) is over 20% uranium-235. HEU is one of the explosive components of nuclear bombs and is also used in nuclear submarine reactors, research reactors, and plutonium production reactors. Fresh HEU for these purposes typically contains 93% or more uranium-235. HEU is not used in commercial electricity producing reactors. Because of its military applications, HEU is classified as a "highly strategic material".

fuel reprocessing:

Spent fuel reprocessing is the process of breaking down spent reactor fuel by chopping it up and putting it through a series of chemical baths that allow extraction of enriched uranium, plutonium-239 and -238, and other isotopes (such as krypton). At the same time large quantities of liquid high-level radioactive waste are produced. The plutonium-239 and enriched uranium can be used for new fuel or nuclear bombs. Plutonium-238 is used as a heat source in satellites. Krypton is a radioactive gas valued for its use in leak and penetration testing of electronic assemblies.

Fuel reprocessing is not essential to commercial nuclear electricity generation, but is fundamental to producing plutonium for nuclear weapons. The high cost of reprocessing and its waste management problems, combined with the relative low cost of uranium, make it much cheaper to mine uranium than to make non-military reactor fuel from reprocessed uranium and plutonium.

plutonium:

Plutonium is a highly toxic, heavy, radioactive, metallic element. It is an extremely dangerous substance because of its radioactivity and the fact that when ingested it deposits in the bone and is excreted very slowly. Inhalation of only a few thousandths of a gram will lead to death within a few years and much smaller quantities can cause lung cancer after a latent period of 20 years or more.

It should be handled by remote control using extreme precaution to avoid the release of dusts to the atmosphere. Plutonium metal is highly reactive and thus must be stored at low temperatures in dry air to avoid corrosion. It is a human-made element, though traces do occur naturally. It was first identified in experiments at the University of California in 1940, and plutonium-239 was isolated a year later. There are 16 isotopes of plutonium, of which only five are produced in significant quantities: plutonium-238, -239, -240, -241, -242.

Plutonium-239 is formed by the irradiation of uranium-238, and has the highest neutron yield of the three primary fissionable materials (the other two being uranium-235 and uranium-233). The purest form of plutonium, called "super-grade", is produced in the blanket surrounding the core of a breeder reactor and in military production reactors such as at the Savannah River Plant in South Carolina, U.S.A.

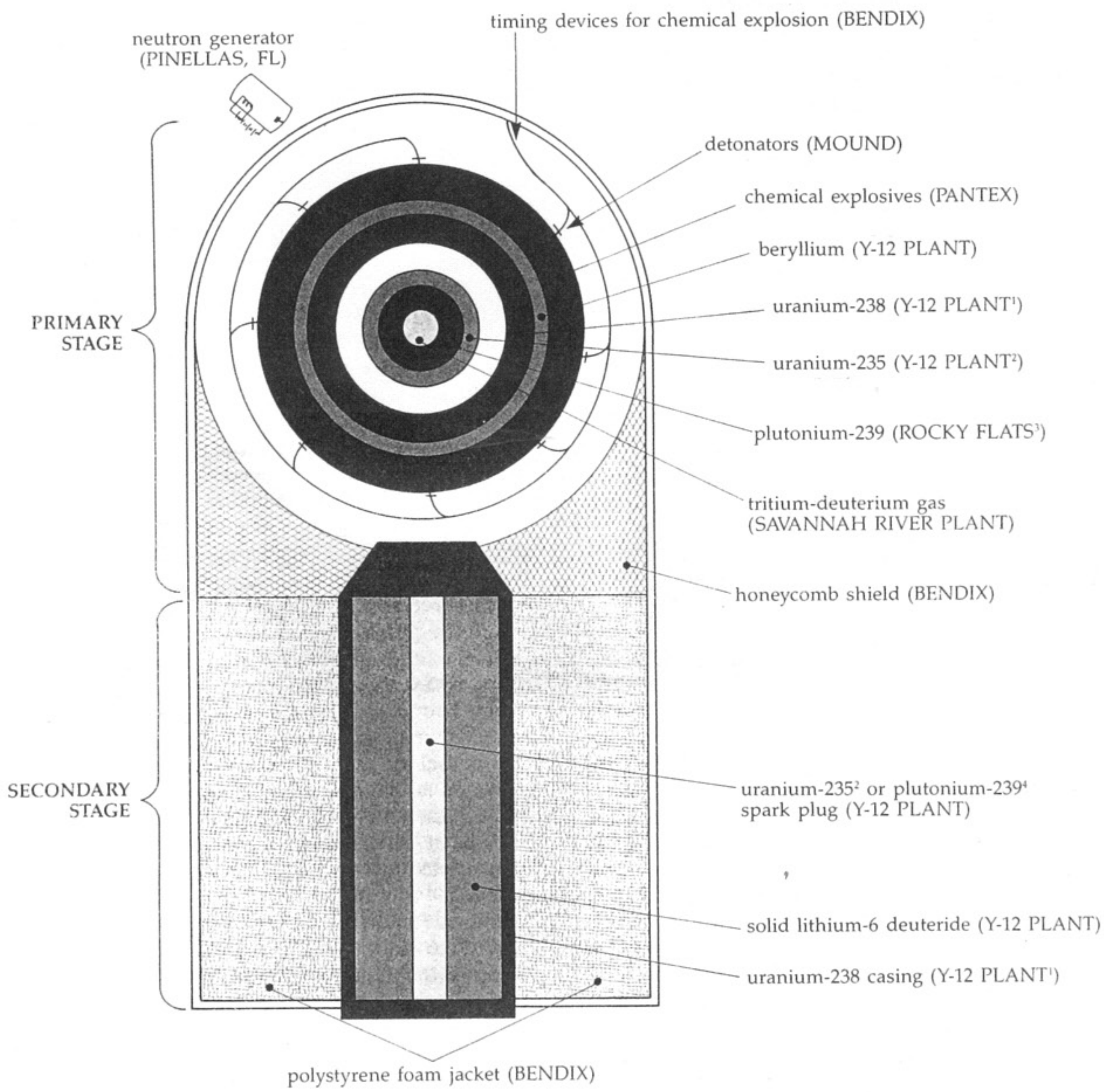
tritium:

Tritium is produced by bombarding lithium with a neutron source of enriched uranium. Tritium is also formed when the heavy water reactor coolant absorbs neutrons (deuterium, or hydrogen-2, absorbs a neutron and changes into hydrogen-3, or tritium). There are several grams of tritium in a nuclear warhead, which regulate and enhance the fusion explosion in nuclear bombs. With a half-life of 12.3 years, tritium decays at a rate of about 5.5% per year. The tritium in nuclear bombs must be replaced every 8 to 10 years.

* * * *

Figure 1

Schematic Cross-Section of H-Bomb

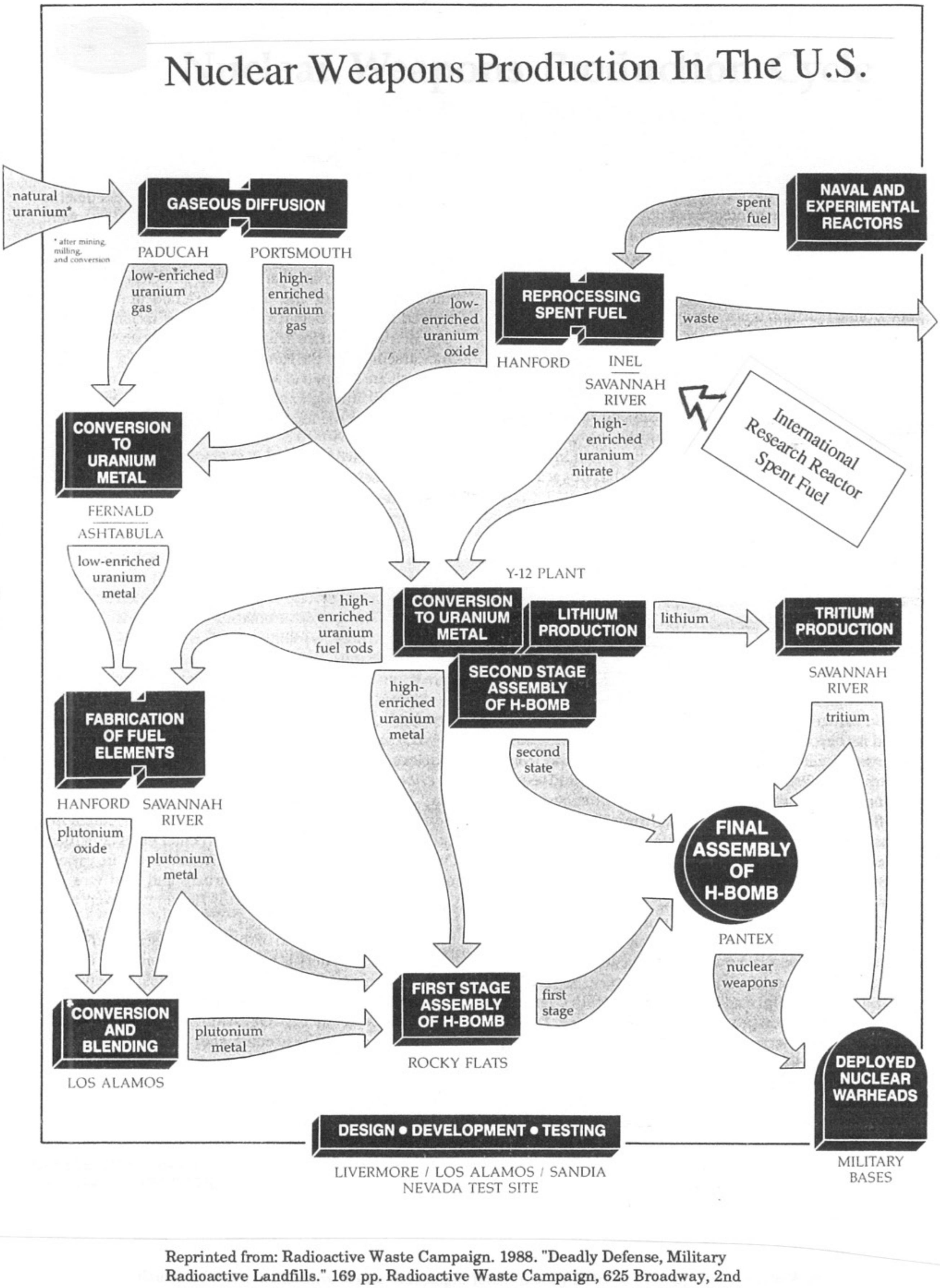


Adapted from drawing by Howard Morland in At Work in the Fields of the Bomb, *Robert del Tredici, 1987.*

[1]uranium-238 is sent to the Y-12 PLANT from FERNALD
[2]uranium-235 is partially enriched at PADUCAH, then sent to PORTSMOUTH for high enrichment, then to Y-12 PLANT
[3]plutonium-239 is manufactured at SAVANNAH RIVER PLANT or HANFORD, then sent to ROCKY FLATS PLANT by way of LOS ALAMOS
[3]plutonium-239 is manufactured at SAVANNAH RIVER PLANT or HANFORD, then sent to Y-12 PLANT

Reprinted from: Radioactive Waste Campaign. 1988. "Deadly Defense, Military Radioactive Landfills." 169 pp. Radioactive Waste Campaign, 625 Broadway, 2nd floor, New York, New York, U.S.A. 10012. ISBN: 0-96190728-2-7. See p. 20.

Figure 2



Reprinted from: Radioactive Waste Campaign. 1988. "Deadly Defense, Military Radioactive Landfills." 169 pp. Radioactive Waste Campaign, 625 Broadway, 2nd floor, New York, New York, U.S.A. 10012. ISBN: 0-96190728-2-7. See p. 34. The "International Research Reactor Spent Fuel" box has been added.

Appendix 1: Certifikat nr S/23/B(M)F (rev 4) (20/85)

SKI STATENS KÄRNKRAFTINSPEKTION
Swedish Nuclear Power Inspectorate

KONCEPT

Datum · Date
1985-10-10
Ert datum · Your date

Vår · Our ref.
5.4.1/891/85
Er · Your ref.
S/TR 17/35

Certifikat nr S/23/B(M)F (rev 4)
(20/85)

CERTIFIKAT

<u>för godkännande av transport av radioaktivt material</u>

Härmed intygas att statens kärnkraftinspektion, i samråd med statens strålskyddsinstitut, som behörig myndighet i Sverige i enlighet med gällande transportbestämmelser, ref 1-3 har <u>godkänt transport</u> av 4 st behållare innehållande vardera <u>12 st bestrålade</u> <u>MTR</u>-bränsleelement. Transporten sker med landsvägs- och <u>sjö</u>trafik med <u>emballage</u> vars kolliprototyps identitetsbeteckning är S/23/B(M)F.

<u>Kolliprototypens egenskaper är följande:</u>

Typ: B(M)F

Kollikategori: III-Gul

Nukleär säkerhetsklass: II (två)

Tillåtet antal: 13 (tretton)

<u>Materialbeskrivning:</u>

Den kombinerade transporten 34:2 och 35:1 innehåller totalt <u>48 st MTR-standardelement</u> uppdelade på fyra kollin med 12 element i varje.

Totala mängden uran i de 48 MTR-elementen är 6 612 g, varav <u>4 821 g U-235</u>.

<u>Avsändare:</u>

Studsvik Energiteknik AB, Studsvik, Sverige

<u>Mottagare:</u>

DoE:s Savannah River Plant, SC., USA

<u>Transportör:</u>

Skandiatransport AB, Göteborg (land)
Atlantic Container Line AB, Göteborg (sjö)

Justering		Samråd				Handläggning	
Datum	Signatur	Datum	Signatur	Datum	Signatur	Datum	Signatur
851016	[illegible]					851017	[illegible]

Certifikat nr S/23/B(M)FT (rev 4)
(20/85,

Transport av detta kolli skall ske i enlighet med vad som anges i referenserna 1-5 samt i enlighet med vad som anges i bilaga 1.

<u>Resteffekt och aktivitetsinnehåll:</u>

Totalt 2 079 W respektive 641 kCi. Maximalt i ett kolli 535 W respektive 164 kCi.
(Beräknat per den 11 november 1985)

Detta certifikat fritar ej avsändaren från att iakttaga alla föreskrifter i varje land till eller genom vars territorium kollit transporteras.

Sista giltighetsdag för detta certifikat är 1986-12-31.

HUVUDENHETEN FÖR TILLSYN
Materialenheten

Paul Ek

Ingegärd Rehn