



# MINISTRY OF DEFENCE

## Historical Accounting for UK Defence Highly Enriched Uranium

A report by the Ministry of Defence on the role of historical accounting for Highly Enriched Uranium for the United Kingdom's Defence Nuclear programmes

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## **HISTORICAL ACCOUNTING FOR UK DEFENCE HIGH ENRICHED URANIUM**

### **INTRODUCTION**

In July 1998 the Government of the United Kingdom issued its Strategic Defence Review (SDR), which declared the total size of the defence stock of nuclear materials. In addition the SDR recommended that a process of declassification and historical accounting of the UK's defence fissile material produced since the beginning of the defence nuclear programme should be carried out. A report on the first phase of this process, covering Plutonium, was published in April 2000. This report on the second phase of this process covers High Enriched Uranium (HEU) used in defence programmes. For the purpose of this report the IAEA definition of HEU has been adopted ( $U^{235}$  content is greater than or equal to 20%).

The objective of the second phase of this process was to establish from the start of the UK's nuclear programme through to 31<sup>st</sup> March 2002 how much defence HEU had been acquired by the UK, how much had been used, and to compare this historic data with the current stock as of 31<sup>st</sup> March 2002.

The data examined during this process was and remains highly classified, and after careful review it has been judged that much of the underpinning detail cannot be published in this report. This is because of the need to protect defence-sensitive information on the design of the UK weapon stockpile and the performance of the nuclear submarine fleet. Information from the early years could also be of value to aspiring proliferators and the UK as a Nuclear Weapon State has to be mindful of its obligations under Article 1 of the Non Proliferation Treaty when considering declassification. The issues affecting early records (explained later in this report) will have a bearing on the absolute accuracy and completeness of any historical accounting of fissile material. Nevertheless, new summary information on the historical UK position is presented here for the first time.

### **POLICY**

The UK believes that transparency about fissile material acquisition for defence purposes will be necessary if nuclear disarmament is to be achieved; since achieving that goal will depend on building confidence that any figures declared for defence stockpiles of fissile material are consistent with past acquisition and use. This report is a contribution to building such confidence.

### **BACKGROUND**

#### **HEU**

Uranium is the heaviest of all the naturally occurring elements and like other elements it occurs in different isotopic forms (different forms of the same element only varying by the number of neutrons in the nucleus of the atom). Natural Uranium as found in the earth's crust is a mixture largely of 2 isotopes: uranium-238 ( $U^{238}$ ) accounting for more than 99% and  $U^{235}$  accounting for less than 1%. There are various methods for enriching natural uranium into High Enriched Uranium (HEU); the Gaseous Diffusion Process and the Centrifuge Enrichment Process are the most common.

#### **ACQUISITION**

The UK obtained HEU for its military programme from two sources:

- The Gas Diffusion Plant at BNFL Capenhurst; and
- Special Nuclear Material (SNM) Exchanges under the “1958 Agreement” with the US Department of Energy (DOE)

## **USE**

The UK Ministry of Defence has used and continues to use HEU for both the nuclear weapons and naval propulsion programmes (with the latter supporting not only the UK’s SSBN fleet but also a fleet of SSNs). In addition, HEU has also been and still is used in a number of test reactors (a naval propulsion test reactor at the Naval Reactor Test Establishment (NRTE) Dounreay, a small high neutron flux research reactor (VIPER) at Aldermaston, a materials test reactor (HERALD) at Aldermaston that is now being decommissioned and an already decommissioned research and training reactor at Greenwich). Consequently the UK has used up some of the HEU it has acquired in weapons tests and experiments and in reactors. In addition some material has become waste.

## **UK FACILITIES INVOLVED IN THE DEFENCE HEU CYCLE**

Various UK sites have been involved with the management of HEU for both nuclear weapons and Naval reactor activities. It should be noted that over the life of these programmes many of the UK sites have changed names and ownership, and that some firms and laboratories are no longer in existence.

At the start of the UK nuclear programme, the Ministry of Supply was the lead organisation until the United Kingdom Atomic Energy Authority (UKAEA) was formed in 1954. In 1971 British Nuclear Fuels Limited (BNFL) was established from the production activities of the UKAEA. The Capenhurst and Sellafield sites have been involved in the defence HEU cycle. Sellafield is the current name for the BNFL portion of the site formerly known as Windscale (a small UKAEA enclave on the Sellafield site is still called Windscale).

In 1950 nuclear weapons design work was moved from Fort Halstead to the Atomic Weapons Research Establishment (AWRE) at Aldermaston, which was then part of the UKAEA. AWRE transferred to MOD ownership in 1973, and in 1987 it was brought together with former Royal Ordnance Factories at Burghfield and Cardiff in order to form the Atomic Weapons Establishment (AWE) and thus to integrate all aspects of the nuclear weapons production programme under one management. AWE now comprises only the Aldermaston and Burghfield sites, as Cardiff has now been decommissioned. Management arrangements for AWE were radically changed in 1993 when legislation was put in place creating AWE as a Government Owned Contractor Operated (GOCO) entity.

Cores for the submarine fleet are designed and manufactured by Rolls Royce at Derby. They are then sent to Barrow for incorporation in new boats or to Devonport for incorporation during refits.

The Nuclear Decommissioning Authority (NDA), a non-departmental public body, was set up in April 2005 under the Energy Act 2004 to take strategic responsibility for the UK’s civil nuclear legacy. BNFL and UKAEA are now contractors managing nuclear sites on behalf of the NDA.

The organisations and facilities that have been involved in handling HEU for defence purposes are:

### **Atomic Weapons Establishment**

HEU has been handled at two of the AWE sites;

- **Aldermaston**, which is involved with weapons-related R&D activity, and fissile material processing and storage.
- **Burghfield**, which is involved in the assembly of weapons and their dismantlement.

## **BNFL**

BNFL facilities used in the HEU cycle were;

- **Capenhurst**, which was set up as the sole UK enrichment site to produce enriched uranium for both civil and military applications. Capenhurst stopped production of HEU for military purposes in 1962.
- **Sellafield**, where an HEU residue recovery plant was established in the 1960s, but closed in the late 1980s, and where “spent” naval reactor cores are sent for long term secure pond storage.

## **Rolls Royce**

- **Derby**, carries out research, design and production for the UK Naval reactor programme, relying on AWE for the supply of HEU and for the initial fabrication into reactor fuel.

## **Shipyard and Dockyard Facilities**

- **Barrow** is the sole nuclear submarine construction yard.
- **Devonport** is now the sole UK nuclear refit yard, though others have been involved in the past (Rosyth and Chatham).

## **UKAEA**

- **Dounreay**, which has been involved in research, manufacture, fuel examination and reprocessing of relatively small amounts of HEU test reactor fuel. The fuel was subject to international safeguards while at Dounreay.

## **Other**

There are also a number of small facilities at other sites that have been involved in military work (mainly small laboratories used for analysis and quality assessment). The quantities of materials at these sites have been measured in grammes.

## **RECORD REVIEW**

### **Details of the Review**

The objective of the historical accounting process was to establish as accurately as possible the total quantity of HEU acquired and how this material was transferred between sites and used.

Records were raised when material was transferred between sites (and within sites for local accounting procedures). This review has been conducted from an audit of annual accounts and the delivery/receipt records at sites. A major problem encountered in examining the records was that a

considerable number had been destroyed for the early years of the programme. There is only a legal requirement for the companies to keep such records for 30 years. In some cases older records were destroyed when they reached this age. There is a greater awareness now of the need to keep these records and this past practice has now been stopped, but too late for the purposes of this review. The task of locating early records was intensive and great efforts were made by all concerned to locate corroborating older records, but the search cannot claim to be comprehensive.

Even where records have survived other problems have been encountered, including:

- not all records differentiated between civil and military production, so assessments had to be made of the ultimate destination. This was complicated by the fact that HEU produced at Capenhurst subsequently went to Windscale for processing before onward movement to the final customer, making distinction between new make and recycled HEU difficult
- some early records make no specific mention of waste and effluent disposals
- some records lacked the precision now required; no units of mass identified, or were difficult to decipher, against the quantities, and consequently assessments had to be made to establish units. Other records did not identify quantities to decimal places and may have been rounded. As individual figures this may be acceptable but when accumulated into total quantities it can produce inaccuracies in final figures
- in some cases no indication of enrichment value was available. Average figures were used, or knowledge of the process used to assure that the material was indeed HEU
- changes in the structure of the contractors have presented difficulties in tracing documentation

It also has to be borne in mind that instrumentation and measurement techniques were not as accurate in the early years as they have become over the past 20 years or so

## **Results of the Review**

A summary account of acquisitions and removals of HEU is shown in the table below;

TOTAL HEU ACQUISITION    26.36 tonnes Uranium

- TOTAL HEU REMOVAL        4.72 tonnes Uranium

= BALANCE                    21.64 tonnes Uranium

This compares to:

TOTAL AUDITED STOCK (at 31 March 2002) = 21.86 tonnes Uranium

The Material Unaccounted For (MUF) is the difference between the amount of material accounted for in this exercise and the total audited stock, ie. an apparent gain of 0.22 tonnes Uranium. The difference between the total audited stock as at 31 March 2002 and the book inventory resulting from the review of records is therefore about 1% of the former. This discrepancy is understandable given the missing records, the difficulties of interpreting remaining records, and measurement inaccuracies particularly in the early years of the programmes. These difficulties have led to a protracted review period to produce this paper, hence the cut-off date of 31<sup>st</sup> March 2002 for the data. The total audited stock is consistent with that reported in the 1998 SDR.

## **MATERIAL ACCOUNTANCY AND PHYSICAL PROTECTION**

MoD HEU is held outside international safeguards for defence purposes, but is subject to a strict materials accountancy regime. Site operators are responsible for accurate accountancy of the quantity and location of the HEU held. Their arrangements for this must include robust internal audit arrangements. In addition, the MoD conducts independent audits of the site accounts and conducts physical inventory checks to verify the on-site inventory.

HEU owned by the MoD is stored and processed at various civil and military sites within the UK. Protection against unauthorised removal or use is provided by a broad range of physical and procedural methods to give defence in depth. These include:

- perimeter and secondary perimeter fences fitted with Perimeter Intruder Detector Systems.
- armed MoD or UKAEA Police at critical sites and installations
- access control into process or storage buildings and electronic monitors to detect unauthorised removal of radioactive material
- locked and sealed transport and storage containers and movement in High Security Vehicles, escorted by armed MoD Police.

## **CONCLUSIONS**

Two main conclusions can be drawn from this study:

- First and foremost, despite the lapse of time and the inadequacies of the records, it has proved possible, with persistence, to demonstrate reasonable agreement between the quantity of HEU acquired and used in the past and the quantity verified to be in the stockpile at 31 March 2002.
- Second, the difficulties encountered in this study reinforce the desirability for future disarmament efforts of those sites that are still handling fissile material for military purposes, or outside safeguards, ensuring that their activities are accurately monitored and properly recorded, and that those records are then retained.