

## SECTION 4

# HISTORICAL MATERIAL BALANCE

This section provides information on the elements used in constructing the historical material balance. Also provided is a discussion on the data limitations incurred during the data-gathering phase of this report. Due to data limitations, the material balance has been calculated in terms of uranium-235, the fissile isotope of uranium used in nuclear weapons.

### ELEMENTS OF THE MATERIAL BALANCE

The historical material balance is comprised of five primary elements: acquisitions, removals, classified transactions, calculated inventory, and actual inventory. Acquisitions and removals are broken down further into material balance categories. Acquisitions contain three material balance categories and removals contain seven. Additional information on acquisitions and removals is provided in Sections 5 and 6, respectively.

The methodology used to determine the calculated U.S. HEU inventory is to subtract the total quantity of removals from the total quantity of acquisitions and classified transactions for a given period. The calculated inventory is then compared to the actual inventory at the end of the given period.

### ACQUISITIONS

Acquisitions increase the U.S. HEU inventory. From 1945 through September 30, 1996, the U.S. acquired a total of 864.4 MTU-235 contained in HEU. The three material balance categories that comprise acquisitions are as follows:

- **Production from uranium enrichment processes** includes HEU produced from electromagnetic separation and gaseous diffusion processes. The Y-12 Plant calutrons produced HEU from electromagnetic separation, whereas the Oak Ridge and Portsmouth Gaseous Diffusion Plants produced HEU from gaseous diffusion.
- **Production from blending** occurs when HEU is mixed with either depleted, natural, or LEU to form a new HEU product. This new HEU product will have an assay lower than

### Methodology

#### Summarize Acquisition Quantities

- ✓ Production from uranium enrichment processes
- ✓ Production from blending
- ✓ Receipts from foreign countries

#### Summarize Removal Quantities

- ✓ Refeed at the enrichment plants
- ✓ Nuclear tests and wartime detonations
- ✓ Fission and transmutations
- ✓ Normal operating losses
- ✓ Transfers to foreign countries
- ✓ Down blending
- ✓ Inventory differences

#### Determine Calculated Inventory by Subtracting Removals from Acquisitions and Classified Transactions

#### Compare and Analyze Calculated Inventory with Actual Inventory

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the original HEU, and the uranium-235 in the non-HEU blend stock will be added to the HEU inventory. Production from blending occurred primarily at the Y-12 Plant.

- **Receipts from foreign countries** includes the receipt of HEU from foreign countries primarily under Agreements for Cooperation for the Peaceful Uses of Atomic Energy. Also included is the receipt of HEU from the former Soviet Republic of Kazakhstan.

## REMOVALS

Removals decrease the U.S. HEU inventory. From 1945 through September 30, 1996, the U.S.

b(5) removed a total of <deleted> contained in HEU. The seven material balance categories that comprise removals are as follows:

- **Refeed at enrichment plants** is the reintroduction of HEU, which has been previously produced as a finished product, back into the enrichment process. HEU was removed from the inventory and refeed into the Y-12 Plant calutrons and the Oak Ridge and the Portsmouth Gaseous Diffusion Plants. This removal is necessary so that quantities of HEU produced are not double-counted.
- **Nuclear tests and wartime detonations** include the expenditure of HEU in 1,054 U.S. nuclear tests and one wartime detonation from 1945 through 1992. Since 1992, the U.S. has not conducted any nuclear weapons tests.
- **Fission and transmutations** account for HEU consumed by nuclear irradiation as a result of exposure in a reactor. The largest consumers of HEU were the Savannah River Site production reactors and the Naval Nuclear Propulsion Program reactors.
- **Normal operating losses** account for HEU in waste, which is determined to be technically or economically unrecoverable. Quantities of HEU in spent fuel and HEU expended in weapons testing activities are not considered normal operating losses.
- **Transfers to foreign countries** include the transfer of HEU to foreign countries under two types of Agreements for Cooperation: (1) peaceful uses of atomic energy, and (2) mutual defense purposes.
- **Down blending** removals occur when HEU is mixed with either depleted, natural, or LEU to form a new product that is not HEU (less than 20 percent uranium-235). The uranium-235 in the HEU blend stock is thereby removed from the HEU inventory. Down blending of HEU occurred primarily at the Y-12 Plant.
- **Inventory differences** are the differences between the quantity of nuclear material on hand at a facility, according to each facility's accounting records system, and the quantity measured during a physical inventory. Inventory differences can be positive or negative. In this report, inventory differences are treated as a removal from the inventory since the cumulative inventory difference for all U.S. facilities is a positive quantity, which is an apparent loss of material.

**CLASSIFIED TRANSACTIONS**

Classified transactions are those transactions that remain classified for national security purposes. From 1945 through September 30, 1996, a total of <deleted> was acquired through classified transactions. b(5)

**CALCULATED INVENTORY**

As shown in Table 4-1, the U.S. acquired a total of 864.4 MTU-235 in HEU from 1945 through September 30, 1996. During the same period, <deleted> in HEU were removed from the U.S. inventory, resulting in a calculated inventory of 620.3 MTU-235 contained in HEU. The 620.3 quantity includes <deleted> of transactions that remain classified. b(5)

*Table 4-1 Historical Material Balance of Uranium-235 in HEU*

<b>Material Balance Category</b>		<b>MTU-235</b>	
<b>Acquisitions</b>	Production from Uranium Enrichment Processes	859.2	
	Production from Blending	0.3	
	Receipts from Foreign Countries	4.9	
	<b>Total Acquisitions</b>	<b>864.4</b>	
<b>Removals</b>	Refeed at Enrichment Plants	114.2	
	Nuclear Tests, Wartime Detonations, and Naval Reactor Use	31.9	
	Fission and Transmutations	56.2	
	Normal Operating Losses	4.9	
	Transfers to Foreign Countries	<deleted>	b(5)
	Down Blending	1.5	
	Inventory Differences	3.2	
	<b>Total Removals</b>	<deleted>	b(5)
<b>Totals</b>	Total Acquisitions	864.4	
	Minus Total Removals	<deleted>	b(5)
	Plus Classified Transactions	<deleted>	b(5)
	<b>Equals the Calculated U.S. HEU Inventory</b>	<b>620.3</b>	
<b>Actual U.S. HEU Inventory as of September 30, 1996</b>		<b>MTU-235</b>	
		<b>620.3</b>	

**HIGHLY ENRICHED URANIUM: STRIKING A BALANCE**

**ACTUAL INVENTORY**

As discussed in Section 3 of this report, the actual U.S. HEU inventory as of September 30, 1996, was 740.7 MTU containing 620.3 MTU-235.

**INVENTORY ANALYSES AND DATA LIMITATIONS**

An accurate material balance in terms of uranium was not possible due to the data limitations described below. However, a material balance in terms of uranium-235 was accomplished yielding a calculated inventory (620.3 MTU-235) that equaled the actual inventory (620.3 MTU-235). It should be noted that even though a balance in terms of uranium-235 was obtained, some uncertainty remains due to data limitations.

b(5)  
b(5)

If a material balance was performed using just the total uranium data, the calculated U.S. HEU inventory would be 731.1 MTU compared to an actual U.S. HEU inventory

of 740.7 MTU. This results in a variance of 9.6 MTU between the inventories. This variance can best be explained through the blending of depleted, normal, and LEU with HEU at the Y-12 Plant. Quantities gained by blending at the Oak Ridge Y-12 Plant prior to 1976 were not available and, therefore, were not included in the material balance. While omission of the quantities blended would have a minimal effect on the uranium-235 balance because of the small amount of uranium-235 in LEU, it could significantly understate the total uranium produced from blending.

In addition to incomplete blending data, other data limitations were encountered during the preparation of this report. Some of the data were extracted from historical sources originally compiled for reasons other than for HEU accountability. As a result, some judgments were necessary in interpreting and adapting the information to satisfy the requirements of the historical material balance. In addition, some data associated with inventory differences were available only in terms of uranium-235.

The information in this report is based on the evaluation of available records and represents the Department's best judgment. The information contained in this report may be updated or revised in the future should additional or more detailed data become available.

**Historical Material Balance  
(in terms of uranium-235)**

	<u>MTU-235</u>
Total Acquisitions	864.4
Total Removals	<deleted>
Classified Transactions	<deleted>
<b>Calculated Inventory</b>	<b>620.3</b>
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<b>Actual Inventory</b>	<b>620.3</b>