SECTION 1 INTRODUCTION

PURPOSE OF THIS REPORT

The release of this report is a result of President Clinton's goal for greater openness in Government; commitments made by the Secretary of Energy at the February 6, 1996, Openness Press Conference (DOE 1996a); and new declassification initiatives. This report covers over 50 years of U.S. HEU activities from the beginning in 1945 through September 1996 and contains important newly declassified information regarding U.S. production, acquisition, and uses of HEU. This new information, coupled with previously declassified data, allows DOE to issue a comprehensive unclassified report on the U.S. inventory of HEU. This report strikes a balance between national security and the DOE's[3] commitment to conduct business in an open environment.

Purpose of this Report

- ✓ To inform the public about the U.S. Government's historical HEU activities.
- ✓ To aid in discussions of HEU storage, safety, and security with stakeholders.
- ✓ To encourage other nations to declassify and release similar data.
- ✓ To demonstrate the Department's commitment to openness in government.

For the 50 years during the Cold War era, the DOE produced and used HEU for a variety of purposes. Initial efforts in the 1940s focused on producing HEU for nuclear weapons. Beginning in the 1950s, HEU was used for other purposes such as naval propulsion reactors, research reactors, and nuclear power plants. Most HEU was produced, utilized, and consumed in a classified environment at geographically dispersed locations and under the auspices of several Federal agencies and departments. In the mid-1960s, production of HEU for nuclear weapons was discontinued. The breakup of the Soviet Union and the end of the Cold War provided an opportunity for the United States to re-evaluate its policies and practices related to classification and declassification of information. Consequently, the consolidation, analysis, and declassification of HEU inventory data was not possible until the end of the Cold War, and HEU was declared excess to national security needs and available for disposition.

The information in this report should aid DOE in discussions with stakeholders related to uranium storage, safety, and security. The publication of this data should encourage other nations to declassify and release similar data. Additionally, this data will assist those responsible for formulating policies with respect to the identification and disposition of excess nuclear materials.

The information in this report is based on the evaluation of available records. The information contained in this report may be updated or revised in the future should additional or more detailed

[3] The term DOE includes DOE and its predecessor Government organizations, i.e., the U.S. Army Corps of Engineers Manhattan Engineer District, the Atomic Energy Commission, and the Energy Research and Development Administration.

data become available. The release of this report does not threaten U.S. national security, run counter to our nuclear nonproliferation policy, or undermine the nuclear deterrence activities of the U.S. For more specifics on declassified information, refer to *Drawing Back the Curtain of Secrecy, Restricted Data Declassification Decisions, 1946 to the Present* (DOE 2000).

METHODOLOGY

This HEU report was prepared from data contained in facility material control and accountability (MC&A) records, historical MC&A summary reports, and individual site inventory and transaction data as reported in the Nuclear Materials Management and Safeguards System (NMMSS). When site MC&A records or NMMSS data were not available, historical reports and memoranda were used to augment these data.

The MC&A system is used to document all nuclear material transactions, compare records with inventory, calculate material balances, and analyze differences to verify that nuclear materials are on hand in quantities as reported. Typically, the number of transactions used to track the production, movement, and removal of HEU from the inventory is in the hundreds of thousands per year. Many of these records currently exist only in summary form, particularly for the period prior to 1969 when the Atomic Energy Commission's (AEC's) nuclear materials accounting system was first automated.

Methodology

Establish Framework

- ✓ Define acquisition categories
- ✓ Define removal categories
- ✓ Peer review of analytical framework

Gather Data

- ✓ Identify sources of data for each category
- ✓ Compile data on historic site missions

Assign Quantities to Acquisition and Removal Categories

- ✓ Compare data between sources
- ✓ Identify double-counted and unquantified materials
- ✓ Identify data gaps and develop assumptions
- ✓ Calculate inventory

Compare Calculated with Actual Inventory

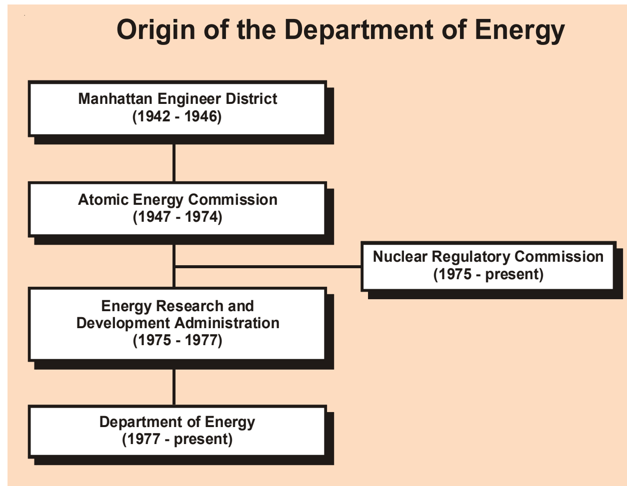
Peer Review of Report

Since the early 1970s, the NMMSS has been the official U.S. nuclear materials accounting system and is used to track U.S. nuclear material inventories, maintain compliance with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and support International Atomic Energy Agency (IAEA) safeguards.

When possible, site data were evaluated and compared to MC&A and NMMSS reports. A major difficulty in the preparation of this report was the absence of some detailed site records, which distinguished between low enriched uranium (LEU) and HEU. Even though MC&A procedures require accounting for the blending of LEU with HEU, availability of data and implementation of these MC&A blending requirements varied among sites, making accounting for the quantities blended difficult. These factors contributed to the accuracy of the material balance, the amount of time required to complete this report, and added to the difficulty associated with interpreting historical summary reports that were available only in terms of total enriched uranium.

Origin of the Department of Energy

Pre-Manhattan Engineer District: 1939–1942



Before World War II, the community of nuclear physicists was small and news of new theories or experimental results spread rapidly among the individuals. This occurred when a number of European physicists came to the United States to avoid political persecution in their native countries, such as Germany and Italy. These physicists brought with them the news that two German physicists, Otto Hahn and Fritz Strassmann, had split the uranium atom in late 1938, and Germany was pursuing development of the atomic bomb.

In July 1939, two immigrant physicists, Eugene Wigner and Leo Szilard, interrupted Albert Einstein's vacation on Long Island to brief him on the splitting of a uranium atom and the possibility of a chain reaction releasing vast quantities of energy. Einstein agreed to help alert the Federal government to the potential danger by sending a letter to President Roosevelt. The letter was drafted by the 1938 Nobel Prize winner Enrico Fermi in cooperation with other physicists at Columbia University. Einstein signed the letter on August 2, 1939 and forwarded it to a friend, Alexander Sachs, for delivery to the President at the earliest opportunity.

That opportunity became imminent when Germany invaded Poland on September 1, 1939; however, Sachs was unable to meet with President Roosevelt until October 11, 1939. When the President understood the potential danger, he authorized Fermi's group to study the possibility of developing a fission weapon before Germany. This was the start of the nuclear arms race.

While Fermi was developing the theory of the chain reaction and demonstrating the practicality of a nuclear reactor, Alfred Nier at the University of Minnesota completed the first separation of uranium-235 and uranium-238 in February 1940. The separated samples were used by Columbia University to prove that the uranium-235 atom underwent nuclear fission when struck by a slow neutron while uranium-238 did not. This information was used by the president of the Carnegie Institution, Vannevar Bush, and the president of the National Academy of Science, Frank Jewett, in a meeting with President Roosevelt to convince him to fund the creation of the National Defense Research Council (NDRC).

The NDRC was the first organization to consolidate nuclear research in the Federal government and provide an articulate lobby within the executive branch. James Bryant Conant, then president of Harvard, was named head of the NDRC. He initially requested $140,000 for research and construction of a carbon pile reactor. He was given $40,000 for research; but nothing for construction.

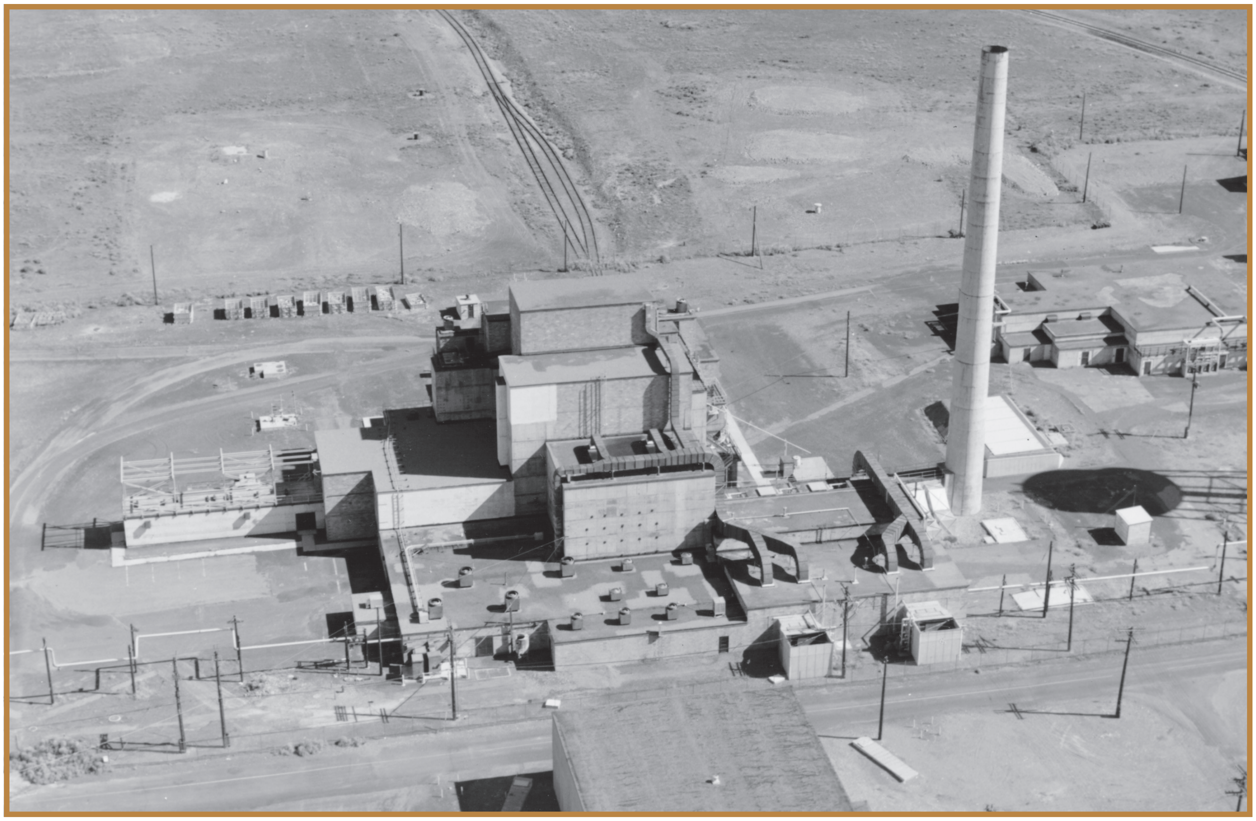
The power struggle for funding between the NDRC, university laboratories, and other organizations hindered U.S. research into atomic weapons. This struggle led to the creation of the Office of Scientific Research and Development (OSRD) in June 1941, which was given wide authority over all government science programs involved in the war effort. Vannevar Bush was named to administer the agency.

In January 1942, a month after the Japanese attack on Pearl Harbor, President Roosevelt approved the development of the atomic bomb. Vannevar Bush realized that a massive construction project was needed to comply with the President's request. He negotiated with the U.S. Army Corps of Engineers (COE) and agreed to put an Army officer in overall charge of the project in exchange for $54 million (about 60 percent of the COE's 1943 budget). During the summer of 1942, Colonel James C. Marshall was put in charge of the atomic weapon project, which was called "The Laboratory for the Development of Substitute Metals (DSM)." Colonel Marshall moved his office from Syracuse, New York, to New York City where he set up the Manhattan Engineer District on August 13, 1942. Under Colonel Marshall, the atomic bomb project was renamed the "Manhattan Project." On September 17, 1942, Colonel Leslie R. Groves replaced Colonel Marshall as head of the Manhattan Project. Colonel Groves was promoted to Brigadier General in late September when he moved the project's headquarters to Washington, D.C.

Manhattan Engineer District: 1942–1946

Between 1942 and 1946, the Manhattan Engineer District spent approximately $2.2 billion on developing production facilities and towns in Oak Ridge, Tennessee; Richland, Washington; and Los Alamos, New Mexico. By 1945, three uranium enrichment plants (electromagnetic separation, gaseous diffusion, and thermal diffusion) had been built at Oak Ridge, and three plutonium production reactors had been built at Richland.

The Manhattan Project was a success because it consolidated multiple independent research projects scattered across the United States into a single program to produce the materials and assemble and deliver three functional atomic weapons (Trinity, Little Boy, and Fat Man) in time to affect the outcome of World War II. After Japan surrendered ending World War II, the Manhattan Project continued research into atomic weapons by testing two more atomic bombs in July 1946 (Able and Baker at Bikini Atoll).



Hanford's B Reactor was the first reactor to produce plutonium in the world. Plutonium produced from this reactor fueled the first atomic explosion in the Alamogordo desert on July 16, 1945 ("Trinity"), and it formed the core of the bomb that exploded over Nagasaki, Japan on August 9, 1945 ("Fat Man").

Atomic Energy Commission: 1947–1974

On January 1, 1947, the Atomic Energy Act of 1946 replaced the Manhattan Engineer District with the Atomic Energy Commission (AEC). The AEC was created by Congress to put atomic weapons under a civilian agency that would provide for domestic development and control of atomic energy. The newly appointed Commissioners of the AEC set out to turn the U.S. atomic energy program from a hastily assembled wartime operation into a productive, industrial complex.

At the time of the transfer of responsibilities from the U.S. Army to the AEC, one gaseous diffusion plant existed at Oak Ridge, two plutonium production reactors were in operation at Hanford (one having been shut down), and 35 other facilities were connected with the production of nuclear materials. Since U.S. foreign policy was based on a steadily growing stockpile of nuclear weapons, the AEC recommended in 1947 that material for non-weapon purposes be limited. To address the plutonium shortage, the AEC approved the building of two additional reactors at Hanford.

With the start of the Berlin Airlift and increasing Cold War tensions, another increase in production was imperative. The Hanford B reactor, which had been shut down after the war, was restarted to produce plutonium. To further increase production of HEU, an addition to the Oak Ridge Gaseous Diffusion Plant (K-29 building) was approved in 1948.

However, even with this increase in production, the Joint Chiefs of Staff felt that the U.S. atomic bomb program was inadequate and asked that the total weapons requirement be increased. The urgency of this request was underlined when the President announced on September 23, 1949, that the Soviet Union had exploded their first atomic bomb. As a result, the Oak Ridge Gaseous Diffusion Plant was further expanded with the construction of the K-31 building.

In January 1950, President Truman directed the AEC "to continue its work on all forms of atomic weapons, including the so-called hydrogen or super-bomb." Not knowing the feasibility of such a bomb but wishing to avoid delay between the determination of feasibility and the possible start of weapons production, the AEC proposed to build two new reactors. These reactors were to produce either tritium or plutonium, in response to weapons requirements. These two heavy water reactors would be the primary source for the production of tritium. As soon as President Truman approved this proposal in June 1950, the du Pont Company accepted the responsibility to design, construct, and operate these two reactors at a site located on the Savannah River near Aiken, South Carolina.

With the outbreak of the Korean War in June 1950, production levels were increased once more. On October 2, a joint working group of the Department of Defense (DoD) and AEC personnel submitted a report to President Truman requesting the following:

- The construction of two gaseous diffusion facilities at a new site that would increase the production of uranium-235 by about 125 percent over that authorized in 1949;
- The construction of reactors at the new Savannah River tritium production site to increase the production of plutonium by about 50 percent over that approved by the President in June 1950; and
- The expansion of uranium ore acquisition and processing, weapons fabrication, and weapons storage facilities.

With Presidential approval, the site chosen for the two new gaseous diffusion facilities was the Kentucky Ordnance Works near Paducah, Kentucky. In order to meet the request for a 50 percent increase in plutonium, it was decided that five reactors, instead of just two, should be constructed at the Savannah River plant. By June 1951, construction had begun at both of these sites.

In 1952, the President approved the AEC request to add new reactors at Hanford, to build additional diffusion facilities at Oak Ridge and Paducah and a new gaseous diffusion plant at Portsmouth, Ohio, and to expand ancillary facilities for processing feed materials and fabricating and storing weapons. By February 1956, the expansion program of 1952 was completed.

Although in subsequent years there was an uncertainty about future long-range requirements for plutonium and tritium, the AEC, after consultation with the DoD, approved the construction of a dual purpose (production of plutonium and steam for electrical generation) reactor at Hanford in 1959. The "N-Reactor" began operation in 1963. By the end of 1963, surpluses of nuclear materials were beginning to accumulate. This was reflected in Congressional approval of the Private Ownership of Special Nuclear Materials Act of 1964. Under the Act, the AEC was authorized to sell, lease, or grant nuclear materials to industry for research and development activities.

Studies were initiated in 1963 by the AEC for reductions in materials production as a result of White House and DoD requests. Based on the recommendation of the AEC and the Bureau of the Budget, President Johnson, in his State of the Union Message of January 8, 1964, announced plans to cutback on the production of enriched uranium and plutonium. As a result of the production cutbacks, HEU production at Oak Ridge was terminated, and four nuclear production reactors at Hanford and Savannah River were shut down.

Thus the large growth in the production of special nuclear materials that began in 1942 came to an end. Presidential approval of further studies continued the trend for curtailment of nuclear materials production. By early 1971, only four reactors continued to operate, N-Reactor at Hanford and three reactors at Savannah River.[4]

Energy Research and Development Administration: 1975–1977

In 1975, Congress abolished the AEC with the enactment of the Energy Reorganization Act of 1974. Regulatory authority was transferred to the newly-formed Nuclear Regulatory Commission (NRC), and the AEC's production and research and development activities, including the nuclear weapons complex, were given to the newly-created Energy Research and Development Administration (ERDA). ERDA was created to achieve two goals:

- To focus the Federal government's energy research and development activities within a unified agency whose major function would be to promote the speedy development of various energy technologies, and;
- To separate nuclear licensing and regulatory functions of the NRC from the development and production of nuclear power and weapons.

[4] These reactors were subsequently shut down or placed in standby (DOE 1996b).

Department of Energy: 1977–Present

On October 1, 1977, the Department of Energy (DOE) became the twelfth cabinet-level department in the Federal government with the enactment of the Department of Energy Organization Act of 1977. The DOE assumed all of ERDA's responsibilities and parts of programs of several other agencies. The Department provided the framework for a comprehensive and balanced national energy plan by coordinating and administering the energy functions of the Federal government. DOE's responsibilities included long-term, high-risk research and development for improved energy technology, Federal power marketing, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program.

Since its establishment, the Department has shifted its emphasis and focus as the needs of the nation have changed. During the late 1970s, the Department emphasized energy development and regulation. In the 1980s, nuclear weapons research, development, and production took a priority. Since the end of the Cold War, DOE has focused on environmental clean up of the nuclear weapons complex, nonproliferation and stewardship of the nuclear weapons stockpile, energy efficiency and conservation, and technology transfer and industrial competitiveness.

Today, the Department contributes to the future of the nation by ensuring our energy security, maintaining the reliability, performance, and safety of the nuclear weapons stockpile, cleaning up the environment from the legacy of the Cold War, and developing innovations in science and technology. In addition, the Department has been taking aggressive steps in releasing detailed information on the nuclear weapons complex to the public with the launching of the Openness Initiative.

Openness Initiative

In 1993, the DOE launched the "Openness Initiative" to release many of its files to the public in response to President Clinton's goal of openness in government (DOE 1993a). The President stated that it is a "fundamental principle that an informed citizenry is essential to the democratic process and that the more the American people know about their Government the better they will be governed. Openness in government is essential to accountability…."

The intent of the Openness Initiative was to earn public trust, thereby fostering informed public participation in Government decision making. Recognizing that openness is essential to public accountability and trust, DOE is continuing to aggressively declassify as much information as possible concerning its past and present activities without jeopardizing U.S. national security objectives or aiding world-wide nuclear proliferation. Consequently, on December 22, 1997, the Secretary of Energy announced actions to ensure that the DOE's Openness Initiative becomes "business-as-usual."

DOE conducts a comprehensive review for each and every declassification action, including coordination with other agencies. Information considered for declassification is reviewed for its national security significance, including concern for nuclear weapons proliferation, terrorism, and foreign policy considerations. It is clear that some information requires continued classification under laws, treaties, and regulations in the interest of furthering national security and nuclear nonproliferation objectives.

Summary of Previously Released Data

Although there has been a considerable amount of HEU information released over the years, this is the first time DOE has consolidated the information in a single document.

Summary of Previously Released Data

- ✓ Total quantity of HEU produced at the Oak Ridge Gaseous Diffusion Plant and at the Portsmouth Gaseous Diffusion Plant.
- ✓ Total quantity transferred to the United Kingdom under a Mutual Defense Barter Agreement with the U.S.: [**7.5** MTU]
- ✓ Total HEU inventories at thirteen DOE sites and laboratories, as of December 31, 1993.
- ✓ Historical inventory differences for DOE contractor sites, including the Oak Ridge Y-12 Plant and the Rocky Flats Environmental Technology Site, and NRC licensed facilities.
- ✓ The total quantity and form of HEU declared excess to national security needs, as of September 30, 1995.

Summary of Newly Released Data

DOE continues to deliver on the President's commitment for a more open government. The Department is declassifying information regarding U.S. production, acquisition, and removal of HEU with the issuance of this report. In addition, this report summarizes over 50 years of unclassified information. This new information, when combined with previously declassified data, is allowing DOE to issue a truly comprehensive report on the total U.S. HEU inventory.

Summary of Newly Released Data

Declassifications

- ✓ Historical HEU production by assay.
- ✓ Historical HEU refeed by assay at all gaseous diffusion plants.
- ✓ The total quantity of HEU transferred to the United Kingdom under a Mutual Defense Agreement (Barter plus other agreements): <deleted> b(5)

Material Control and Accountability

The following describes the evolution of DOE's safeguards system and the current U.S. and international safeguards systems.

Safeguards Evolution

From the beginning of the nuclear program in the 1940s through 1954, the U.S. nuclear effort was primarily military in character. During this period, all special nuclear material[5] was U.S. Government property and, with minor exceptions, held by the AEC, AEC contractors operating Government facilities, and the DoD. Physical security systems and operations and security clearances for authorized personnel, coupled with stringent material control measures, were the principal means of protecting special nuclear material.

Nuclear materials accounting records, inventory procedures, and reports were maintained as a matter of prudent management practice to verify that no nuclear material had been diverted or stolen. However, the controls were limited by the accuracy of the measurement techniques and instruments. Over time, improved nuclear material identification and measurement techniques were developed and standardized to support the growing U.S. nuclear program. Even with these improved techniques however, the measurement of nuclear material includes some degree of uncertainty.

Beginning in the early 1950s, nuclear material became available to industry. In 1953, President Eisenhower announced his Atoms for Peace Program, which provided technology and nuclear material to other nations, including nuclear materials for research and power reactor programs. The Atomic Energy Act of 1946 was amended in 1954 to allow civilian peaceful use, though not ownership, of special nuclear material and to allow U.S. assistance to foreign countries developing peaceful nuclear programs.

The AEC chose not to impose its pre-1954 safeguards systems on private (licensed) industry. However, physical security measures continued to be practiced to protect classified materials and technology at licensed facilities. The AEC concluded that licensee contractual financial responsibility for special nuclear material loss or degradation, and the severe criminal penalties provided by the Atomic Energy Act adequately protected the national interest in regard to material theft or diversion.

In the mid-1960s, an amendment to the Atomic Energy Act permitted private ownership of special nuclear material. However, the potential nuclear proliferation issue and problematic experiences with licensees led the AEC to increase requirements on the licensees for the safeguarding of special nuclear material in their possession. Consequently, regulations were

[5] Special nuclear material is defined in the Atomic Energy Act and includes plutonium and enriched uranium.

issued in 1967 to establish specific material control and accounting procedures for licensees.

The following year, the regulatory office in the AEC assumed sole responsibility to oversee materials safeguards applicable to private industry. In response to the increase in international trade in nuclear material, the AEC issued regulations regarding nuclear material physical protection requirements for licensees to protect themselves against terrorist and other threats. This regulatory office formed the foundation for the present NRC, which became an independent agency in 1975.

Elements of the Safeguard System

Nuclear material safeguards at contractor-operated DOE facilities are applied through an integrated system designed to prevent, deter, detect, and respond to attempts at unauthorized possession or use of special nuclear materials. The safeguards system contains the five major elements, as discussed in the text box.

Safeguards System Operation

Physical protection, material control and accountability, and human reliability programs and procedures combine to provide effective material safeguards. Precise and accurate inventory measurement records and statistical evaluation procedures provide independent verification that the physical protection and material control procedures are effective. If statistical analysis indicates any significant anomalies, a detailed investigation is conducted to resolve the differences. By law, the Federal Bureau of Investigation is immediately informed if there is any evidence of theft, diversion, or sabotage of nuclear material.

Elements of the Safeguards System

- ✓ ***Physical Protection*** - to inhibit unauthorized, forceful or surreptitious attempts to gain entry to facilities possessing special nuclear material and to prevent its removal. Physical protection includes the use of perimeter intrusion detection systems; entry and exit controls; vaults; alarms; and containment, concealment, and trained protection forces.
- ✓ ***Personnel Security Programs*** - to inhibit unauthorized acts involving nuclear material through the implementation of security clearance and human reliability programs, and security training and awareness. These programs serve to deter insiders from diverting, stealing, and sabotaging special nuclear materials.
- ✓ ***Material Control*** - to detect or deter theft or diversion of special nuclear material by positively controlling access to and utilization of special nuclear material. Such control consists of material surveillance, internal control procedures, verification of material characteristics and process holdup, material custody, and seals and tags.
- ✓ ***Material Accountability*** - to record all material transactions, compare records with inventory, calculate material balances, and analyze differences to verify that nuclear materials are in quantities as reported and in authorized locations. The materials accounting procedures also detect and verify process holdup in facilities to ensure effectiveness of physical protection practices. Additionally, these procedures help determine levels of protection appropriate for nuclear materials inventories. This is accomplished through measurements, physical inventories, records and reports, audits, and inventory and shipper-receiver difference evaluation and analysis.
- ✓ ***Administrative Controls*** - to assure the above elements are effectively described, implemented, and operated to satisfy safeguards criteria and requirements. These controls include checks and balances to maintain separation of responsibilities between operations and safeguards personnel.

Superimposed on this integrated safeguards system, which is implemented by the DOE contractor responsible for the materials, is a governmental oversight management system designed to review and verify that the DOE contractors are meeting their materials safeguards responsibilities. DOE Headquarters and the responsible field office conduct ongoing surveys and technical audits of their contractors to assure effective implementation of contractor procedures and verification of contractor performance. Inventory differences are carefully analyzed during these surveys, and audits are made to verify and validate the contractor explanations.

DOE Headquarters staff also conduct independent assessments of the total system capabilities and of the performance of its field offices and contractors in effectively safeguarding nuclear materials. Inventory differences and their explanations are again reviewed during these assessments. Finally, independent congressional reviews are performed by the General Accounting Office to address specific topical areas such as materials tracking.

Federal law provides for fines and criminal penalties for conspiracies or attempts to steal special nuclear material. Rewards are authorized for information leading to successful prosecution of anyone involved in a conspiracy to steal, divert, or illegally possess special nuclear material. To date, no such incident involving HEU has occurred.

International Safeguards and Physical Security

International nuclear cooperation was first offered by President Eisenhower in 1953 through the Atoms for Peace Program. In 1954, amendments to the Atomic Energy Act legally enabled nuclear cooperation for peaceful purposes. In 1957, the IAEA was established to promote peaceful nuclear energy and control nuclear material. The NPT entered into force in 1970 and further provided support for international technical cooperation and "fullscope safeguards" by the IAEA. Passage of the Nuclear Non-Proliferation Act of 1978 (NNPA) increased requirements for controlling exported U.S. material. In 1995, an indefinite extension of the NPT continued to strengthen support for technical cooperation and "fullscope safeguards." By 1998, the IAEA was authorized greater access to information and sites under a new Protocol against diversion of nuclear material and for detection of clandestine nuclear programs.

The Atomic Energy Act and the NNPA require that nuclear material exported from the U.S. under agreements for peaceful nuclear cooperation be subject to safeguards and physical protection measures. Agreements for peaceful nuclear cooperation are reviewed by Congress before they can be brought into force. The U.S. relies on the IAEA to apply international safeguards and conducts a program of reciprocal visits and exchanges of information on physical protections.

According to the terms of the Atomic Energy Act, the NNPA, and Bilateral Agreements for Peaceful Nuclear Cooperation, most U.S.-origin nuclear material exported is subject to international safeguards applied by the IAEA. Further, Article III (2) of the NPT and IAEA safeguards agreements with countries party to the NPT require IAEA safeguards on all nuclear material in the country, including any material of U.S.-origin. For non-NPT countries, IAEA safeguards are limited to nuclear material transferred under trilateral agreements. In the case of European Union countries, safeguards are also applied by the European Atomic Energy Community (Euratom) under a "partnership" arrangement with the IAEA. U.S. agreements for cooperation also contain provisions for "fallback" safeguards to be applied by the U.S. in the event the IAEA is unable to implement safeguards. Starting in 1961, safeguards inspection rights in U.S. nuclear cooperation agreements were implemented by the IAEA. In Argentina and Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials also applies safeguards under a quadrilateral agreement with the IAEA. A firm policy was thereafter adopted of transferring safeguards implementation to the IAEA as new agreements were negotiated or old agreements were renewed.

IAEA safeguards require facilities to maintain accurate and comprehensive records of nuclear material inventory, including documents and receipts for processing and shipment activities. Such information, down to gram quantities, is provided to national authorities, who in turn provide inventory reports to the IAEA. The IAEA can conduct on-site inspections to verify information provided by the country and to ensure that nuclear material has not been diverted, that nuclear facilities have not been used for unreported production of nuclear materials. The frequency of IAEA inspections at a given facility is determined by the type and quantity of nuclear materials present. Materials posing the highest proliferation risk, such as HEU, which is directly usable in nuclear weapons, are subject to the most frequent inspections, as are facilities capable of producing HEU. Facilities with large amounts of HEU generally have a full-time IAEA inspector present. For countries having small amounts of HEU (for example, neutron sources to calibrate nondestructive assay instruments), IAEA inspections are much less frequent, taking into account inspection costs and the need to make an annual statement regarding attainment of inspection goals.

The IAEA reports its verification activities in the annual Safeguards Implementation Report, with a summary contained in the IAEA Annual Report. These IAEA verification activities provide confidence that the HEU exported by the U.S. has been used only for peaceful purposes.

In 1967, President Johnson offered to place some U.S. facilities under IAEA safeguards. Since 1980, nuclear materials in U.S. facilities not having direct national security significance have been eligible for IAEA safeguards under the 1980 US/IAEA voluntary offer Safeguards Agreement. In 1993, President Clinton offered to place IAEA safeguards on selected nuclear material excess to U.S. defense needs; the IAEA began applying safeguards to excess HEU in 1994.

In addition to IAEA safeguards, U.S. law (the Atomic Energy Act as amended and the NNPA), the NPT, and Agreements for Cooperation with other countries require that adequate physical protection measures be applied to exported nuclear material of U.S. origin. A determination of the adequacy of the physical protection measures to be applied to exported nuclear material is a condition for the export license from the NRC.

Since 1974, in cooperation with the Departments of State and Defense and the NRC, DOE has visited foreign countries and exchanged information on the physical protection of nuclear material. The primary purpose of these visits is to help ensure that U.S. nuclear material provided to foreign countries is protected at the level recommended in international guidelines published by the IAEA in *The Physical Protection of Nuclear Material* (IAEA 1993).

During this time, U.S. experts led by DOE have conducted 125 visits to 41 countries with U.S.-origin enriched uranium. The experts review, with foreign officials, the legal and regulatory basis for physical protection and the perceived threat to nuclear material. The experts visit sites where U.S.-origin and other nuclear materials are used or stored, observe all elements of the sites' physical protection systems, and offer recommendations on improving the system. The factors used to determine what countries to visit include the type and quantity of U.S.-origin nuclear material, the date and findings of the last visit, the perceived threat of theft or sabotage, and impending export license applications for nuclear-related material and equipment.

Elements of the IAEA Safeguards System

- ✓ ***Nuclear Material Accounting*** includes countries reporting information on nuclear program activities and facility design; facility records on the location and quantity of nuclear material under their control; and information to the IAEA based on facility records.
- ✓ ***Containment and surveillance*** includes complementary techniques, such as tamper-indicating seals to prevent undetected movement of material, and film and television cameras or other monitoring devices to detect undeclared activities.
- ✓ ***Inspection*** includes onsite verification by IAEA inspectors of declared information such as reports and records, independent measurements of nuclear materials, and operation of inspection equipment.

Additionally, the DOE works closely with the IAEA to support its new International Physical Protection Advisory Service (IPPAS) that evaluates, for requesting countries, the adequacy of their nuclear material physical protection systems. DOE physical protection experts have participated in IPPAS missions to Bulgaria, the Czech Republic, Hungary, and Romania.

Reduced Enrichment for Research and Test Reactors Program

In the late 1970s, the international community realized that the fuel used in many nuclear research reactors was weapons-usable HEU and could be stolen or diverted for use in nuclear weapons. In 1978, the international community established the Reduced Enrichment for Research and Test Reactors (RERTR) program. Its mission was to develop a substitute fuel (i.e., LEU), which was not suitable for nuclear weapons. As substitute fuels were developed, existing reactors would be converted to LEU, and new reactors would be designed to use only LEU.

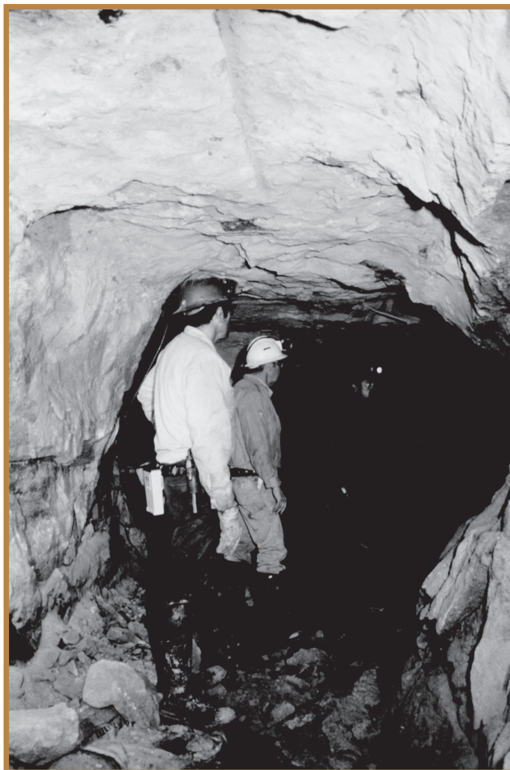
The RERTR program has proven to be remarkably successful, facilitating the conversion of dozens of reactors worldwide from weapons-usable to non-weapons-usable fuel and sharply reducing international commerce in HEU. In 1986, the NRC ordered that all licensed, domestic research reactors, where possible, use LEU. To date, several university research reactors have converted to LEU fuel. As of September 1995, of the 42 foreign research reactors with at least 1 megawatt of power, 37 either had been converted, were in the process of converting, or no longer needed fuel.

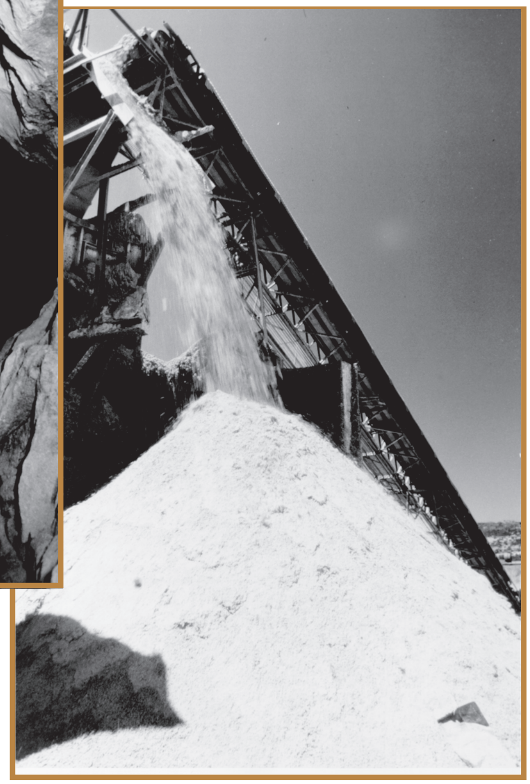
In 1986, the United States suspended the return of U.S.-origin spent nuclear fuel from foreign research reactors. This policy would later be revised. In May 1996, the DOE, in consultation with the Department of State, issued a Record of Decision to recover as much U.S.-origin HEU as possible while assisting foreign research reactor operators with their conversion to LEU.

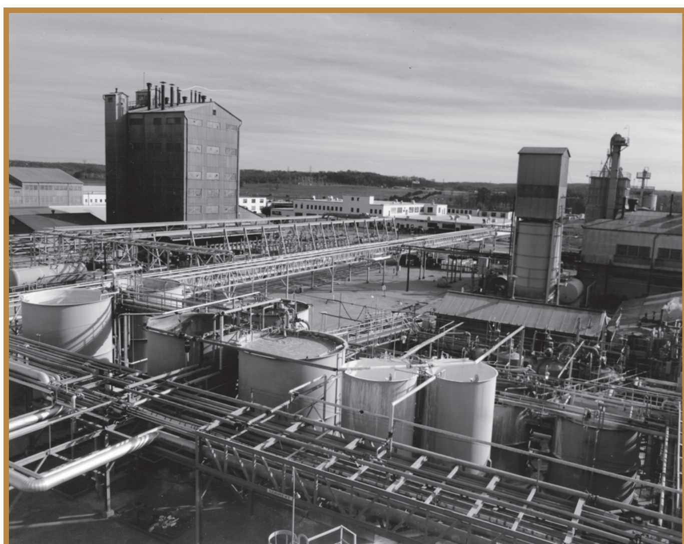
Under the new policy, the first return of research reactor spent fuel was successfully completed in September 1996. It included 8 casks containing 280 elements with a total of approximately 97 kilograms of HEU. An additional three returns were completed in fiscal year 1997, consisting of 15 casks containing 542 elements with approximately 206 kilograms of HEU. During fiscal year 1998, an additional 5 returns were scheduled, including 35 to 40 casks of spent fuel from Europe, Asia, Australia, and South America. [Quantitites from returns in 1997 and 1998 are not included in the historical material balance of this report and are provided to demonstrate the success of the RERTR program.]

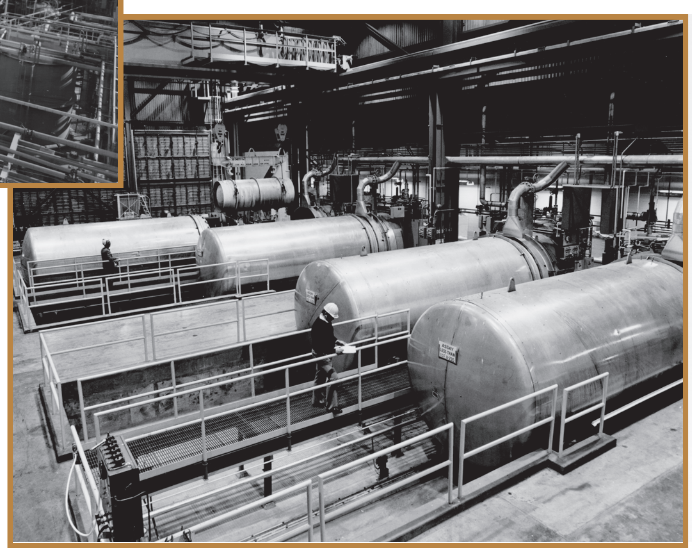
The RERTR program is one of the most successful aspects of the IAEA and the NPT. With the full support of the international community, the RERTR program could entirely eliminate commerce of weapons-usable HEU by the year 2008.

The first step in turning natural uranium into enriched uranium involves mining and milling. Mining and milling involves extracting uranium ore from the earth's crust and chemically processing it. Pictured to the right is an underground mine and a uranium mill at the United Nuclear Homestake Site in Grants, New Mexico.









Refining involves the chemical conversion of uranium concentrates into purified forms suitable as feed material for enrichment processes. The Feed Materials Production Center in Fernald, Ohio (above), was a uranium refinery that processed uranium feed materials into compounds and ultimately into uranium metal. The gaseous diffusion process involves the pumping of uranium hexafluoride gas through miles of piping and barrier-like structures that have millions of uniformly sized tiny holes. The Paducah Gaseous Diffusion Plant in Kentucky (right) is one of the three gaseous diffusion plants that enriched uranium in the United States.