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BY THE COMPTROLLER GENERAL

111839

Report To The Congress

OF THE UNITED STATES

Nuclear Fuel Reprocessing And The Problems Of Safeguarding Against The Spread Of Nuclear Weapons

In 1977 the executive branch reversed its long-standing support for nuclear fuel reprocessing, primarily because of the risk of spreading nuclear weapons. GAO reviewed safeguards technology designed to reduce such risks in Federal reprocessing facilities and found that concerns are warranted. Material in sufficient quantities to construct a nuclear weapon could be diverted and go undetected for a long time.

Effective international control and safeguards over the production, storage, and use of separated plutonium are lacking.

The United States should increase its efforts to

--develop and ensure the use of effective safeguards for reprocessing facilities and

--establish, in conjunction with major nuclear fuel users, suppliers, and reprocessors, an international system to control the storage and use of excess plutonium.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This report discusses the problems of safeguarding nuclear spent fuel reprocessing facilities and concludes that the administration's policy of indefinitely deferring commercial reprocessing within the United States has hampered research and development efforts to improve safeguards technology.

We made our review in response to a congressional directive contained in the Nuclear Non-Proliferation Act of 1978 (P.L. 95-242). This act requires us to study and report to the Congress by March 1981 on the implementation and impact of the act on U.S. non-proliferation policies, purposes, and objectives. This is an interim report presenting the results of our evaluation of the non-proliferation issues associated with commercial spent fuel reprocessing.

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of State; the Secretary of Energy; and the Executive Officer, Arms Control and Disarmament Agency.

Comptroller General
of the United States

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Office of Safeguard
+ Security

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NUCLEAR FUEL REPROCESSING AND THE PROBLEMS OF SAFEGUARDING AGAINST THE SPREAD OF NUCLEAR WEAPONS

D I G E S T

Adequate safeguards to prevent the theft or diversion of weapons-usable material from commercial nuclear fuel reprocessing plants have not yet been developed. Recognizing the risks of nuclear technology and/or materials being diverted from such plants, the President decided in 1977 to indefinitely defer commercial nuclear spent fuel reprocessing in the United States.

The President justified this decision on the basis that the United States can sustain its nuclear power program for the forseeable future without reprocessing and that premature commercialization of reprocessing in the United States could encourage other nations to expand reprocessing activities. In spite of the U.S. policy, many other countries continue to expand their reprocessing programs.

GAO concluded that the administration's policy has hampered research and development of ways to safeguard against the diversion of nuclear material from reprocessing plants for non-peaceful purposes. New technology is needed if the United States is to further its own goals of preventing the spread of nuclear weapons and influence other countries to adopt strengthened safeguards at reprocessing facilities.

U.S. SAFEGUARDS CANNOT ASSURE THAT DIVERSIONS OF WEAPONS-USABLE MATERIAL WILL BE DETECTED

Reprocessing is the chemical separation of usable uranium and plutonium from burnt, or spent, nuclear power reactor fuel. The recovered plutonium can be recycled as fuel for reactors, reducing the demand for uranium ore. The major disadvantage of reprocessing is that it produces plutonium, which can be used to construct a nuclear weapon.

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Safeguards systems used at Federal reprocessing plants cannot assure that diversions of weapons-usable material for non-authorized purposes can be detected in a timely manner. Diversion or theft of material sufficient to construct a nuclear weapon is possible and could go undetected.

Material control and accountability systems cannot accurately measure and account for weapons-usable material in spent fuel rods and in the process and waste streams. Since fiscal year 1955, a net shortage of 145.5 kilograms of plutonium occurred at the Savannah River, South Carolina, reprocessing plant. The Department of Energy assumes that none of this was diverted. It attributes the shortage to inaccurate production estimates, process measurements, shipper/receiver measurements, and accounting and normal operating losses. GAO believes that with existing material control and accountability technology, the Department has no valid basis for this assumption and is thus unable to provide definitive assurance that no plutonium has been diverted. (See p. 10.)

There is no way to measure the precise quantity of weapons-usable material in spent nuclear reactor fuel because measuring instruments needed have not been developed. Consequently, the Department estimates the quantity with a mathematical formula. The average uncertainty of this estimate is believed to be about plus or minus 10 percent. (See p. 12.)

Also, current accountability systems cannot precisely determine the quantity of weapons-usable material being processed. Measurement capability is limited to plus or minus 5 percent. Uncertainties resulting from these measurements are so large that diversions of significant quantities of plutonium might not be detectable in large operating plants. (See p. 16.)

Accurate measurements are also lacking in the radioactive waste portions of reprocessing operations. Although waste streams generally contain only small concentrations of weapons-usable material--less than 1 percent--the lack of instruments to accurately measure the

material leaves open potential diversion paths. (See p. 19.)

Material control and accountability systems do not provide timely information on quantities or locations of weapons-usable material. If material were diverted, it is doubtful that the diversion could be discovered in time to recover the material before it could be converted into a form suitable for weapons. (See p. 20.)

The Department relies on physical security to ensure the integrity of its material control and accountability systems. However, physical security systems at the Federal reprocessing facilities are limited in their effectiveness to prevent theft of material. (See p. 21.)

The Department recognizes the limitations of material control and accountability and physical security systems at Federal reprocessing facilities and is acting to upgrade them. However, the Department has not comprehensively identified these systems' limitations or developed an approach to provide for as much safeguards protection as may be necessary. Until the current systems are thoroughly evaluated and a plan for safeguarding material is developed and implemented, weapons-usable material will remain subject to theft or diversion. (See p. 22.)

EFFECTIVE INTERNATIONAL SAFEGUARDS FOR THE PRODUCTION, STORAGE, AND USE OF PLUTONIUM ARE LACKING

The administration's policy of indefinitely deferring commercial reprocessing of nuclear fuel had limited impact on the reprocessing programs and plans of other nations. Nine other nations have reprocessed spent fuel, or are developing plans to do so. International Nuclear Fuel Cycle Evaluation estimates are that 25 tonnes (metric tons) of separated plutonium exist worldwide, and by the year 2000, this will increase to about 885 tonnes.

The large amounts of separated plutonium that exist and that will be produced worldwide

reinforces the need for effective (1) international safeguards to detect diversions and (2) international control over the subsequent storage and use of the separated material. To date, such effective systems and controls are nonexistent. (See p. 30.)

The International Atomic Energy Agency is responsible for assuring that material subject to its safeguards is not diverted for unauthorized purposes. With respect to reprocessing facilities, the Agency will have difficulty meeting this objective since it has no experience safeguarding commercial-size reprocessing facilities. Furthermore, it believes that existing international safeguards are so limited that it could not quickly detect diversions of significant quantities of material if these facilities were currently operating. The major limitations are that

--technical limitations of material control and accountability systems prevent the Agency from independently detecting and verifying material diversions by host nations in a timely manner and

--containment and surveillance systems are not reliable for assuring the integrity of material control and accountability systems.

The International Atomic Energy Agency has established an international working group to comprehensively study safeguards systems and techniques for reprocessing facilities. (See p. 34.)

In light of the number of nations reprocessing or planning to reprocess, excess stocks of plutonium are expected worldwide. To reduce the proliferation risks created by scattered plutonium stockpiles, an international control system over excess plutonium is needed. Such a system does not exist, and partly because of the administration's policy on reprocessing, the United States is throwing less than its full weight behind the proposed international plutonium management and storage regime.

GAO believes the United States could and should be making a more concerted effort to establish an effective international plutonium storage system. The current amounts of separated plutonium and the projections of future stocks underline the importance of establishing such a system promptly. (See p. 38.)

U.S. RESEARCH AND DEVELOPMENT EFFORTS LACK COMPREHENSIVE APPROACH FOR SOLVING REPROCESSING SAFEGUARDS PROBLEMS

U.S. research and development efforts fall short of providing the needed framework to solve reprocessing safeguards problems.

--Deferral of commercial reprocessing within the United States has deemphasized reprocessing safeguards research and development efforts.

--Current reprocessing safeguards research and development efforts lack direction and control.

If commercial reprocessing is to be a safe, proliferation resistant industry, and if the United States is to be in a position to influence and promote its non-proliferation objectives, it must develop effective domestic and international safeguards concepts and technologies. Until such safeguards are developed and appropriate institutional and procedural systems are operating to complement technology, commercial reprocessing will remain a high proliferation risk and a threat to world peace and stability. (See p. 45.)

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

The Secretary of Energy should

--develop comprehensive plans for the Federal reprocessing facilities which identify problems of safeguarding material in these facilities and determine actions that could be taken to develop and implement integrated safeguards systems (see ch. 2) and

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--direct the Office of Safeguards and Security to develop a comprehensive program which systematically identifies reprocessing safeguards needs, establishes research priorities, and provides for a plan to conduct research to solve these problems and to demonstrate integrated safeguards systems for commercial and international application. (See ch. 4.)

RECOMMENDATION TO THE SECRETARY OF STATE

The Secretary of State should intensify the Department's efforts to establish, in conjunction with the major nuclear users, suppliers, and reprocessors, a system to control the storage and use of existing and future international stocks of separated plutonium. This effort could be in conjunction with, or in lieu of, the international plutonium storage regime being studied by the International Atomic Energy Agency. (See ch. 3.)

AGENCY COMMENTS

The Department of State provided informal comments and agreed that the information presented in the report is factually correct. It agrees that international control over the storage and use of separated plutonium is needed. The Department believes, however, that an international plutonium storage regime will not solve proliferation problems unless it is established in a manner that can effectively control the international storage and use of separated plutonium.

The Arms Control and Disarmament Agency provided informal comments which were incorporated in the appropriate sections of the report. The Agency believes that GAO is incorrect in stating that the United States has less than its full weight behind the proposed international plutonium storage regime. The Agency said that the United States has been supportive of an effective international plutonium storage system and was instrumental in launching the ongoing study about such a system.

GAO believes that there is a need for international controls over plutonium storage and use. Presently, the United States can exercise its greatest influence in the establishment of an international plutonium storage system. Although the United States is participating in the ongoing study of such a system, GAO believes the United States can and should be making a more concerted effort to promptly establish as effective and credible a system as possible while the majority of separated plutonium is limited to a few countries.

The Department of Energy provided both informal and written comments which were incorporated in appropriate sections of the report. The Department agrees that more needs to be done to improve security at its own reprocessing facilities and to develop safeguards technology for international application. The Department believes, however, that GAO misleads the reader by linking inventory differences at Federal reprocessing facilities to the safeguarding of commercial facilities against the threat of national proliferation through diversion. The Department believes that safeguards systems at its facilities would differ from systems that would be used in an internationally safeguarded facility located in a non-weapons state.

GAO recognizes and points out in the report the differences between domestic and international safeguards. However, the technological limitations of material control and accountability safeguards noted in this report would be the same for military and/or commercial reprocessing facilities operating within the United States and abroad. These limitations will adversely impact the ability of domestic and international safeguards to detect diversions of weapons-usable material from peacefully dedicated facilities. These same limitations also preclude the Department from assuring that its physical security and material control systems are effective at preventing diversions of weapons-usable material from its facilities. The full text of the Department's written comments and GAO's evaluation are included in appendix I.

Contents

ABBREVIATIONS

ACDA	Arms Control and Disarmament Agency
AEC	Atomic Energy Commission
DOE	Department of Energy
GAO	U.S. General Accounting Office
IAEA	International Atomic Energy Agency
INFCE	International Nuclear Fuel Cycle Evaluation
MUF	Material Unaccounted For
OSS	Office of Safeguards and Security
Pu	Plutonium
SAGSI	Standing Advisory Group on Safeguards Implementation
U	Uranium

CHAPTER 1

INTRODUCTION

The nuclear power era aroused concern that nations could divert nuclear technology and/or supplies for non-peaceful purposes. Six nations already are known to have exploded nuclear devices--the United States, the Soviet Union, the United Kingdom, France, the Peoples Republic of China, and India. Other countries--Israel and South Africa--are thought to have nuclear weapons capability. In addition, many non-weapons nations are developing nuclear power programs to meet their energy needs. In 1977, the Nuclear Energy Policy Study Group estimated that by 1985, the nuclear power programs of over 30 nations will be producing enough plutonium for each to make at least a few bombs. 1/

In April 1977, the President renewed an effort to reduce the threat of nuclear weapons proliferation. As a major part of this effort, he reversed the executive branch's long-standing support for commercialization of nuclear fuel reprocessing within the United States.

Reprocessing is the chemical separation of usable uranium and plutonium from burnt, or spent, nuclear power reactor fuel. The recovered plutonium can be recycled as fuel for reactors, reducing the demand for uranium ore. The major disadvantage of reprocessing is that it produces plutonium, which can be used to construct a nuclear weapon.

Reprocessing plays a pivotal role in the nuclear fuel cycle and the future programs of nations which view the nuclear power option as a long-term source of energy. Many nations which anticipate the use of nuclear energy for their long-term energy needs are concerned about the future supply and availability of uranium ore. Nations without indigenous natural energy resources often view reprocessing as an important step in not only reducing their reliance on energy imports, but also in preparing for next generation breeder reactors.

Breeder reactors require reprocessing of current and future stocks of spent reactor fuel in order to obtain the necessary plutonium as fuel. Breeders, to some nations, offer the economic and political benefits of semi-energy independence, as they produce more fuel than they consume, and can thereby fuel additional reactors to meet increasing

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1/Nuclear Energy Policy Study Group, Nuclear Power Issues and Choices (Cambridge, Mass: Bollinger Publishing Co., 1977).

energy demands. The decision to proceed with reprocessing and breeder reactors, therefore, is a national decision, based on both economic and political factors. The United States currently has deferred commercial reprocessing and redirected its efforts away from early commercialization of breeder technology, while a few nations such as France and Japan have not.

U.S. DEFERRAL POLICY INTENDED TO REDUCE THE RISK OF WEAPONS PROLIFERATION

In the past, the United States contributed to the spread of reprocessing technology by encouraging the worldwide development of reprocessing as an integral part of nuclear power development. After India exploded a nuclear device in 1974, however, it became apparent that foreign nations could use such "sensitive" technology to make weapons. 1/ Since that explosion, the United States has acted to limit the spread of reprocessing technology. This action culminated in April 1977, when President Carter established a policy which called for (1) an indefinite domestic deferral of commercial spent fuel reprocessing, (2) a redirection of research aimed at finding more proliferation-resistant nuclear energy technologies, and (3) an international evaluation of nuclear energy, taking into consideration its potential for weapons proliferation.

The President justified the decision to defer commercial nuclear spent fuel reprocessing on the basis that (1) nuclear power in the United States could be sustained for the forseeable future without nuclear fuel reprocessing and recycling and (2) premature commercialization of reprocessing in the United States might encourage other nations to do likewise. The administration was particularly concerned that if other nations were to construct reprocessing facilities, the risk of nuclear proliferation would increase because existing safeguards systems were believed to be inadequate.

1/"On May 18, 1974, Indian scientists detonated a nuclear explosive ostensively designed for peaceful applications * * *. Apparently, both Canadian and U.S. materials were used by the Indians in the production of plutonium for the 1974 nuclear explosive device." Taken from "Export of Nuclear Fuel to India, Hearings and Markup Before the Committee on International Relations," House of Rep., 95th Cong., Second Session, May 23 and June 8 and 14, 1978, pp. 2 and 24, respectively.

As a result of the 1977 policy, licensing hearings for the first large commercial reprocessing facility within the United States were terminated. The Department of Energy (DOE) initiated a Non-Proliferation Alternative Systems Assessment Program to identify nuclear power systems and to recommend strategies to implement those alternatives possessing high proliferation resistance, efficient resource use, technical and economic feasibility, commercial potential, and acceptable public safety and environmental characteristics.

Also, the International Nuclear Fuel Cycle Evaluation (INFCE), with over 60 participating nations and organizations, was established in October 1977. This effort is directed at identifying measures which can minimize the dangers of weapons proliferation without jeopardizing the development of nuclear energy for peaceful purposes. A final report, released in February 1980, was the evaluation's end result. One of INFCE's eight working groups evaluated the proliferation issues surrounding nuclear fuel reprocessing, and identified measures which could be used to reduce its proliferation risks. (For additional details about the results of INFCE and the reactions of other nations to the U.S. policy, see Chapter 3.)

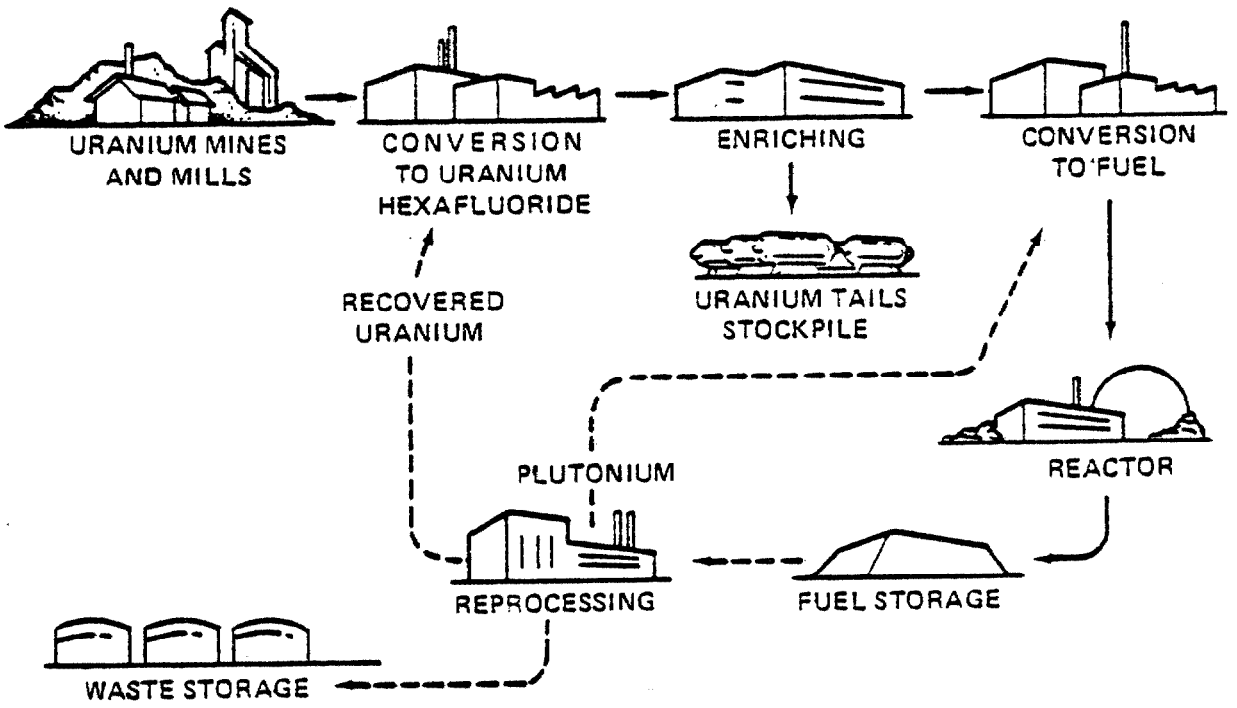
REPROCESSING AND THE NUCLEAR FUEL CYCLE

The nuclear fuel cycle consists of a number of processes, beginning with the mining and milling of uranium ore, and ending with the final storage of radioactive waste products. The diagram on page 4 indicates the various stages of the fuel cycle.

After the uranium has been mined, milled, and refined, it goes through a process called enrichment. Uranium enrichment involves separating the two principal forms of uranium (U) found in nature--U-235 and U-238--to obtain a product which has a higher concentration of U-235. This is necessary because most commercial nuclear reactors require fuel which contains about 3 percent U-235. However, uranium in its natural state contains only about 0.7 percent U-235 and about 99.3 percent U-238. Uranium products of higher enrichment--up to 95 percent U-235--are used for weapons purposes.

Once the uranium has been enriched to about 3 percent it is fabricated into reactor fuel elements. During reactor operation, some of the U-238 is converted into plutonium-239 (Pu), a fissionable material. The spent

THE LIGHT WATER REACTOR NUCLEAR FUEL CYCLE



fuel removed from the reactor generally contains about 1 percent U-235 and 0.8 percent plutonium; both are still reusable. The balance of the spent fuel is U-238 and small amounts of nuclear waste products.

Reprocessing is a chemical separations process that recovers usable uranium and plutonium from burnt, or spent nuclear reactor fuel. The reprocessing operation basically consists of dissolving the spent fuel; chemically separating the uranium, plutonium, and wastes; and concentrating the final products. The recovered uranium and plutonium can be recycled as fuel for light water or breeder reactors.

The United States, Belgium, France, West Germany, India, Italy, Japan, the Soviet Union, and the United Kingdom have been reprocessing spent reactor fuel for several years. Within the United States, reprocessing has supported both the weapons and naval nuclear propulsion programs, and at one time, the commercial nuclear power industry. Currently, two DOE owned and operated facilities--Savannah River and Idaho Chemical Processing plants--are operating to support the

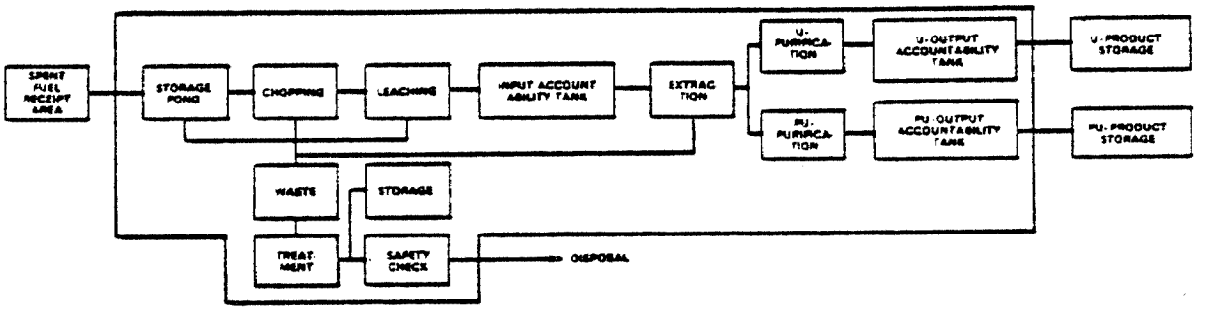
defense and naval programs, and a third--Purex Fuel Reprocessing Plant at Richland, Washington--has been on standby status since September 1972. Commercially, the only facility to have operated within the United States--Nuclear Fuels Services, Inc., West Valley, New York--closed down in 1972 after operating for 6 years. Another facility--Allied General Nuclear Services' Barnwell, South Carolina plant--was under construction and in the process of being licensed to operate at the time of the 1977 policy statement, but construction and licensing have since terminated. All of these facilities are based on the Purex solvent extraction process, which separates out streams of recovered uranium and plutonium solutions. Preliminary results from the INFCE effort indicate that a number of nations will probably use the Purex process in future commercial reprocessing facilities. (The diagram on page 6 shows the procedure followed in the typical Purex process.)

Once the spent fuel assemblies are received by the facility, they are stored in pools of water for cooling purposes until a sufficient number of assemblies are on hand to initiate the processing of a fuel batch. After removal of the excess hardware from the fuel assemblies, the remaining fuel rods are sheared (chopped) into small pieces and immersed in a nitric acid solution that leaches the fuel meat from the cladding (waste). This results in an acid solution that contains essentially all of the nuclear material and the residual pieces of fuel cladding called "hulls," that are considered to be a radioactive waste. The hulls are separated from the acid solution, flushed or cleaned with additional solution, and generally stored before disposal. The hulls can be compacted or given other treatment for volume reduction prior to storage and/or disposal.

The acid solution containing the nuclear material is transferred to an input accountability tank where it is measured and sampled to determine the quantity of plutonium and uranium being processed. The solution then undergoes a solvent extraction process where an organic solvent removes the uranium and plutonium from the acid solution, leaving a highly radioactive nitric acid solution waste stream that is measured and sampled for nuclear material content prior to being sent to specially constructed tanks for storage.

The uranium and plutonium are separately removed (stripped) from the organic solvent by slightly acidic aqueous solutions and separately further purified and concentrated by solvent extraction or ion exchange circuits. The final product solutions are sent to product-sampling tanks

SIMPLIFIED FLOW DIAGRAM OF THE
COMMERCIAL SOLVENT EXTRACTION PROCESS



where they are sampled and measured to determine the respective quantities of uranium and plutonium they contain, which, added to the losses found in the waste streams, ensures that all the uranium and plutonium is recovered.

An essential difference between the current Purex process, as described, and that used by the DOE-owned plants that were constructed over 25 years ago is that the DOE-owned plants do not use a chop-leach process in their headend but declad the irradiated fuel elements with special chemical solutions that dissolve the cladding but not the fuel. This then gives an additional liquid waste stream of moderate radioactivity that is measured, sampled, and sent to waste tanks.

REPROCESSING AND ITS RELATIONSHIP TO NUCLEAR WEAPONS PROLIFERATION

Nuclear material suitable for making a weapon could be obtained either during enrichment or reprocessing. If the uranium is highly enriched it can be used to make a nuclear explosive. The International Atomic Energy Agency's (IAEA's) Standing Advisory Group on Safeguards Implementation (SAGSI) considers about 25 kilograms (or about 55 pounds) of highly enriched uranium (uranium enriched to 90 percent or more) sufficient for one nuclear explosive. The IAEA's SAGSI considers about 8 kilograms of plutonium (or about 17.6 pounds) enough for one nuclear explosive device.

Reprocessing poses a particular proliferation risk because the technology is widely available and the facilities are complex and difficult to safeguard. Reprocessing is a liquid process in which most equipment is inaccessible during operation--which is 24 hours a day, 7 days a week, for extended periods of time. During the early stages, processing must be carried out behind thick shielding because of high radioactivity levels. Measurement vessels are likewise hidden from view, so that direct observation is not possible. In addition, the enormous amount of piping, number of tanks, and recycled solutions make it difficult to monitor all flows at all times within a plant. Given the complex nature of reprocessing and the large amounts of plutonium in various forms, many opportunities exist to conceal a diversion.

ROLE AND PURPOSE OF SAFEGUARDS

Since weapons-usable material present in the fuel cycle could be stolen, controlling it is of utmost importance. In order for the United States' and other nations' peaceful nuclear power programs to continue, assurance against diversions of material for unauthorized purposes must be provided and verified. Safeguards are designed to provide such assurance on both a national and international level.

Within the United States, DOE is responsible for assuring that DOE reprocessing facilities are adequately safeguarded to prevent sabotage and theft of weapons-usable material, and its detection. It views terrorists and/or civilians as adversaries capable of attacking and/or working from inside the facility. DOE safeguards systems are comprised of both material control and accountability and physical security. Ideally, these subsystems interact to provide a capability to detect both abrupt diversions of significant quantities of weapons-usable material, and protracted diversions of lesser amounts over an extended period of time. The Nuclear Regulatory Commission would fulfill a similar safeguards role as DOE if commercial reprocessing facilities operated.

On the international level, the IAEA is responsible for assuring that material subject to its safeguards is not diverted for unauthorized purposes. It relies on a nation's safeguards system to detect and prevent diversions by subnationalist groups or citizens, and views

the reprocessing nation as a potential adversary. Its role is to assure the continued use of nuclear fuel cycle facilities for peaceful energy purposes, and to inform the international community if and when diversions occur.

METHODOLOGY AND SCOPE OF REVIEW

This review was undertaken to determine the relationship between commercial spent fuel reprocessing and worldwide weapons proliferation and the adequacy of safeguards technology to detect diversions of weapons-usable material and subsequently reduce the proliferation risk of commercial reprocessing. To do this, we reviewed (1) the adequacy of existing reprocessing safeguards measures, (2) the impact of the administration's reprocessing policy on reprocessing plans and programs of other nations, and (3) DOE's efforts to develop and demonstrate improved reprocessing safeguards measures for both domestic and international application. We did not attempt to evaluate the impact that the current U.S. policy is having on the future of nuclear energy within the United States.

Information contained in this report was obtained by interviewing officials from DOE, the Department of State, and the Arms Control and Disarmament Agency (ACDA). We determined the adequacy of safeguards technology to detect and/or prevent diversions of weapons-usable material by reviewing safeguards systems used within two DOE operating facilities. Since these facilities operate in support of the U.S. military program, DOE officials pointed out that the safeguards used at these plants would differ from the safeguards systems that would be used in a commercially operating, internationally safeguarded facility. Since Federal facilities were the only reprocessing facilities operating in the United States at the time of our review, we assessed the effectiveness of the safeguards technology being used at these facilities, placing particular emphasis on those elements of the systems that would have applicability to a commercial facility subject to international safeguards. We then visited the Tokai Mura reprocessing plant in Japan, which is currently a test site for advanced international safeguards instrumentation, to gain an understanding of those safeguards problems in the U.S. facilities which are common to internationally safeguarded, commercial facilities. Finally, in order to determine state-of-the-art developments in safeguards technology and the technological problems that remain, we reviewed the ongoing safeguards research at major laboratories within the United States. This research is being conducted in support of the U.S. safeguards program as well as IAEA's expert group on reprocessing plant safeguards.

Foreign response to the President's 1977 policy statement was obtained by (1) reviewing documentation submitted to INFCE and (2) interviewing foreign government and utility officials from Japan, Belgium, France, the United Kingdom, West Germany, and Austria; U.S. embassey officials from South Korea, The Netherlands and Spain; and officials from IAEA and the European Atomic Energy Supply Group.

CHAPTER 2

U.S. SAFEGUARDS CANNOT ASSURE THAT DIVERSIONS OF WEAPONS-USABLE MATERIAL WILL BE DETECTED

Safeguards systems used by DOE at Federal reprocessing plants cannot assure that diversions of weapons-usable material for non-authorized purposes can be detected in a timely manner. Diversion or theft of material sufficient to construct a nuclear weapon is possible and could go undetected.

--Material control and accountability systems are unable to account for weapons-usable material in a timely manner.

--Physical security systems cannot assure that theft of weapons-usable material will be prevented.

DOE recognizes the limitations of these systems and is acting to upgrade safeguards at these facilities. While the upgrade work may improve the safeguards effectiveness at these facilities, it is uncertain how much the diversion risks will be reduced. DOE has not identified the limitations of existing safeguards systems or developed an approach to provide for as much safeguards protection as may be needed. As a result, we believe that a comprehensive safeguards evaluation plan needs to be developed and implemented to improve the level of safeguards protection at the Federal facilities.

MATERIAL CONTROL AND ACCOUNTABILITY SYSTEMS CANNOT ACCOUNT FOR WEAPONS-USABLE MATERIAL IN A TIMELY MANNER

The objective of DOE's material control and accountability system is to (1) determine the amount of weapons-usable material entering the process, (2) monitor the location and flow of the material in the process, and (3) measure the amount of material coming out in final product and waste streams. Material control and material accountability are two major elements of domestic safeguards systems. Other safeguards measures, such as physical security or containment and surveillance, also represent important elements of domestic safeguards systems because they alert facility personnel that unauthorized people have entered an area where weapons-usable material is contained. However, material control and accountability must be relied upon to account for all material and determine if an actual diversion has occurred.

Material control and accountability can be an effective diversion-detecting tool only if it can accurately measure significant quantities of weapons-usable material in a timely manner. A "significant quantity" is that needed to construct a nuclear device. As stated earlier, IAEA's SAGSI considers significant quantities of weapons-usable material to be 8 kilograms of plutonium or 25 kilograms of highly enriched uranium. In addition to accurate measurements, detection time is another essential element of an effective safeguards system. An effective material control and accountability system must be capable of detecting diversions within the conversion time, or that amount of time required to convert nuclear material into an explosive device. IAEA's SAGSI considers conversion time to be from 1 to 3 weeks for weapons-usable material from a reprocessing facility. In order for a material control and accountability system to be an effective diversion-detecting tool in a reprocessing facility, therefore, it must have the capability to measure weapons-usable material quantities (1) with an accuracy of less than 8 kilograms for plutonium (25 kilograms for uranium) and (2) in a time frame of less than 1 and no more than 3 weeks.

The material control and accountability systems used in Federal reprocessing facilities are not capable of meeting these objectives because

--instruments to accurately measure weapons-usable material being processed are lacking and

--accountability systems fail to show the quantities of weapons-usable material in a timely manner.

As a result, significant quantities of weapons-usable material could be diverted from Federal reprocessing facilities, and the material could be converted to a nuclear weapon before DOE could detect it.

Instruments to accurately measure weapons-usable material quantities in process are lacking

Material control and accountability systems cannot accurately measure and account for weapons-usable material in spent fuel rods and in the process and waste streams. Since fiscal year 1955, a net shortage of 145.5 kilograms of plutonium occurred at DOE's Savannah River reprocessing plant. Inventory differences fluctuated greatly--ranging from plutonium shortages of 62.7 kilograms in fiscal year 1960 to overages of 61.8 kilograms in fiscal year 1965.

DOE assumes that none of this was diverted. It attributes the shortage to inaccurate production estimates, process measurements, shipper/receiver measurements, and accounting and normal operating losses. We believe that with existing material control and accountability technology, DOE has no valid basis for this assumption and is thus unable to provide definitive assurance that no plutonium has been diverted.

Problems in determining weapons-usable material content of fuel rods

Material control and accountability starts with the receipt of spent fuel rods in the storage area. At this point, the fuel rods are counted and an initial determination is made of the quantity of weapons-usable material contained in the irradiated fuel rods and being processed by the plant. From a safeguards standpoint, the input quantity is significant. A facility operator must know the quantity of weapons-usable material being processed so he can determine if any has been diverted or stolen during or after reprocessing.

There is no way to measure the precise quantity of weapons-usable material in spent nuclear reactor fuel because measuring instruments needed have not been developed. Consequently, DOE estimates the quantity with a mathematical formula. The average uncertainty of this estimate is believed to be about plus or minus 10 percent. As a result of this imprecision, there is no way to accurately determine the quantity of plutonium being put in a reprocessing plant, and thus, no way to tell if it all comes out. Whereas DOE officials agree that it is important to determine the plutonium content of fuel rods in commercial facilities, they believe that item accountability of fuel rods in their facilities provides sufficient assurance that subnationalist groups have not diverted weapons-usable material.

The difficulty of accurately determining the content of irradiated fuel rods and the impact and problems it creates for controlling and accounting for material is illustrated by the following. In DOE facilities, physical inventories are taken to determine the quantity of material on hand. This quantity is compared to the book value consisting of the prior month's ending inventory plus receipts less disbursements. The difference between the physical inventory and book value is the inventory difference or material unaccounted for (MUF).

From fiscal years 1955 through 1978, the Savannah River reprocessing plant had a net inventory shortage, or MUF, of 145.5 kilograms of plutonium. The discrepancy was attributed to the following:

Reasons for MUF	Plutonium shortages (overages) in kilograms
Production estimates (the difference between calculated and measured amounts of plutonium recovered in the input accountability tank)	98.3
Measurement uncertainties (caused by inaccurate measuring instruments)	89.2
Shipper/receiver differences (the arithmetic differences between the quantity of material measured by the shipper and by the receiver)	(11.0)
Accounting corrections	(9.8)
Normal operating loss corrections	(21.1)
Other factors	(0.1)
Total MUF	145.5

The data indicate that a shortage of 98.3 kilograms was caused by inaccurate production estimates or the difference between calculated and measured amounts of plutonium. This cumulative difference, however, provides only a partial indication of the magnitude of the accountability problem created by imprecise estimates of plutonium being received by the facility in the spent fuel.

As previously stated, the average inaccuracy of this estimate is believed to be about plus or minus 10 percent. However, the inaccuracy of any one estimate could be much greater than 10 percent. Consequently, large fluctuations in inventory differences occur from one reporting cycle to the next and from one year to the next which, over a period of time, tend to cancel each other out.

The graph on page 15 shows the differences between calculated and measured amounts of plutonium by year at the Savannah River reprocessing plant from fiscal years 1955 through 1978. Yearly differences fluctuated greatly, ranging from overages of 68.8 kilograms of plutonium in fiscal year 1965 to shortages of 56.8 kilograms in fiscal year 1976.

From fiscal years 1955 through 1967, a plutonium overage (receipt estimates understated actual production quantities) of 138 kilograms was reported. During this period, the following adjustments to the plutonium receipt computation formula were made in an attempt to reduce the degree of inaccuracy:

--The equation used to calculate the amount of plutonium in the spent fuel rods received at the beginning of the process was modified in July 1955 because calculated plutonium production was 8 to 10 percent greater than what was actually being recovered.

--The equation was modified in November 1963 to correct a 3- to 5-percent production overestimate.

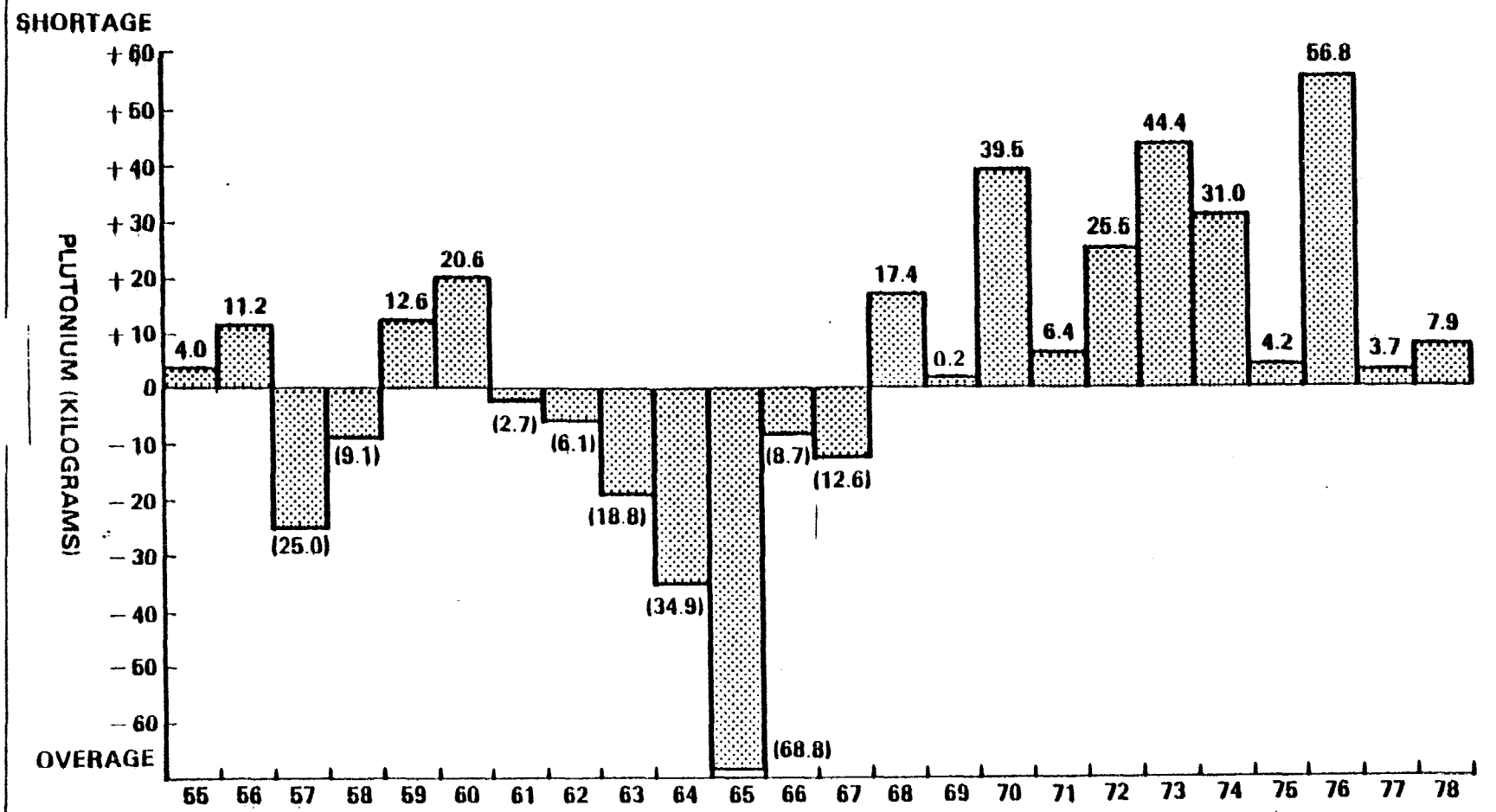
--The equation was modified in April 1967 because plutonium recovered was 4 percent higher than the quantity calculated.

DOE made these adjustments based on historical data and experience. In essence, DOE was adjusting the equation by trial and error to minimize as much as possible material unaccounted for in its production estimates.

In 1968 DOE's predecessor, the Atomic Energy Commission (AEC) changed the enrichment content of the fuel elements, which significantly affected the accuracy of its production calculations. From fiscal years 1968 through September 1978, a plutonium shortage (receipt estimates exceeded actual production quantities) of 237 kilograms was reported. The differences were so large that AEC Operations Office officials requested headquarters to eliminate any differences between plutonium receipt estimates and production from the MUF computation. In his request, the Operations Office Manager stated:

"By using this method, inventory difference caused by inaccurate reactor calculations would be removed from the categories that may be associated with unaccounted for material or losses, or inventory difference, all of which may erroneously connote

ESTIMATE OF PLUTONIUM UNACCOUNTED FOR FROM PRODUCTION ESTIMATES a/ SAVANNAH RIVER REPROCESSING PLANT FISCAL YEARS 1955-1978



a/DIFFERENCE BETWEEN CALCULATED AND MEASURED AMOUNTS OF PLUTONIUM.

missing material. These changes would reduce MUF or inventory differences at Savannah River by about one-half and should aid in gaining public and governmental acceptance of the nuclear industry."

Subsequently, in November 1977, the contractor operating the facility was directed to eliminate inventory differences between calculated and production quantities of plutonium. The contractor was also instructed to reduce the MUF balance by 37.7 kilograms of plutonium to adjust for prior inaccuracies in the plutonium receipt account. DOE considered this action to be an interim procedure until such time as an effective measurement capability could be developed for irradiated fuel.

A DOE Operations Office official stated that the problem of inaccurate plutonium receipt estimates would not be as severe in a commercial operation as it has been in DOE facilities, because the fuel DOE reprocesses varies greatly in composition. These fluctuations make it difficult to refine the mathematical formula to obtain accurate estimates. The DOE official said that estimates of plutonium content in commercial fuel would be more accurate because of relatively fixed uranium composition.

As previously stated, the only commercial reprocessing facility to operate in the United States was the Nuclear Fuels Services plant in West Valley, New York, which ceased operations in 1972. Although this was a small plant [with a capacity of 300 tonnes (metric tons) a year], the differences in plutonium receipt estimates and production for power reactor fuel averaged plus or minus 2.6 percent. In a large-size commercial facility such as was contemplated at Barnwell, this would amount to over 150 kilograms of plutonium unaccounted for in a 6-month period. With inaccuracies and fluctuations of this magnitude, it would be difficult for a facility operator to confirm with any degree of reliability whether a theft or diversion of a significant quantity of plutonium had occurred.

Problems determining weapons-usable material quantities being processed

Current accountability systems cannot precisely determine the quantity of weapons-usable material being processed. Once the fuel rods are dissolved in acid, the solution is transferred to an input accountability tank where the first actual measurement is made. Solution samples are taken to determine density, acid concentration, and uranium and plutonium concentrations; and the liquid

level of the solution is determined. This data is used to determine the total quantity of weapons-usable material in the tank.

Conventional measurement technology for the input accountability tank is one of the least accurate measurements of plutonium in the nuclear fuel cycle. The uncertainty of this measurement at Savannah River ranges from plus or minus 2 to 5 percent for plutonium concentration, plus or minus 2 percent for uranium concentration, and from plus or minus 1 to 3 percent for liquid level of the tank.

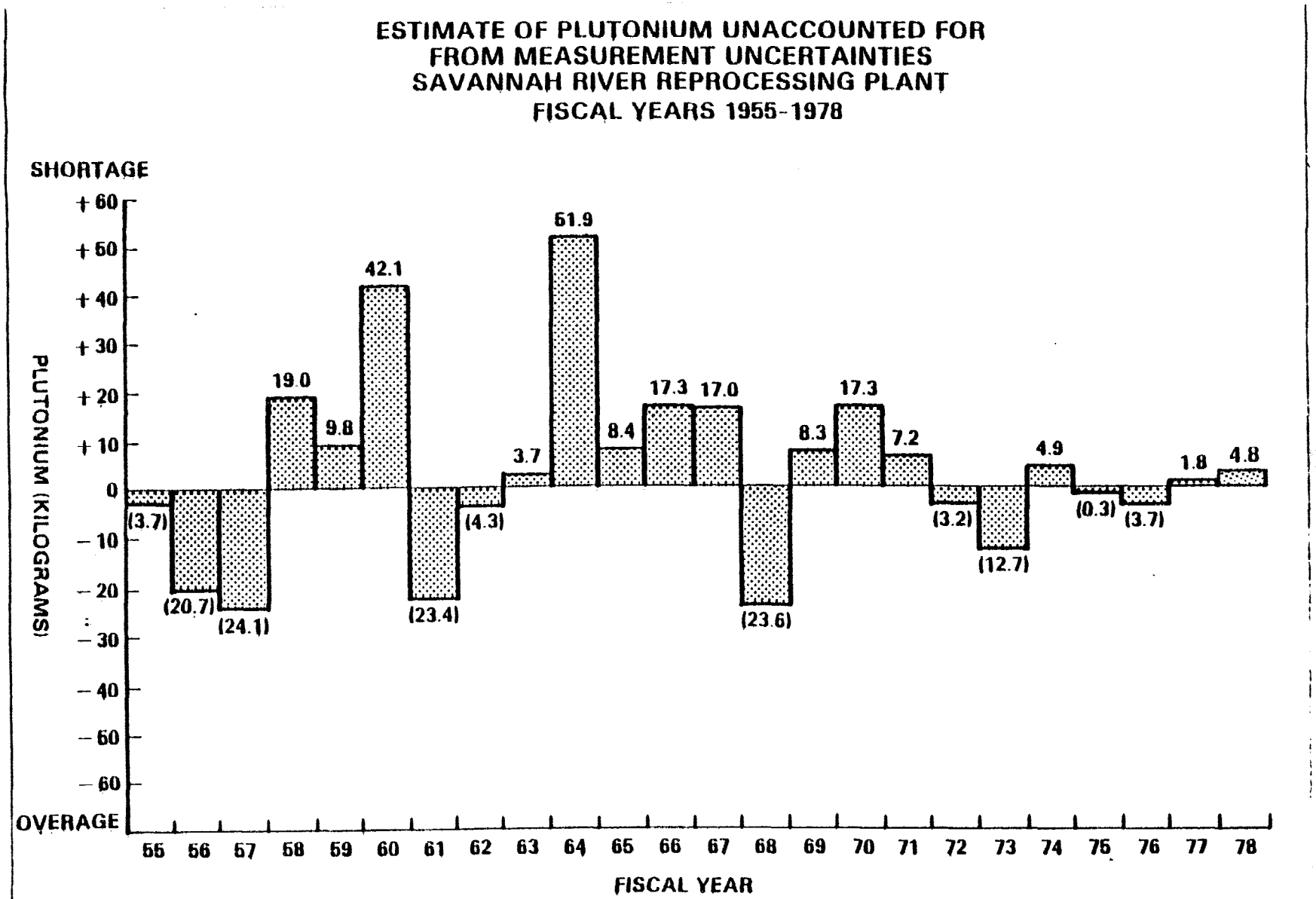
After the accountability tank, material is not measured again until it reaches the product-sampling tank, as instruments do not exist which can measure material during the extraction and purification processes. The adequacy of measurement technology at the final product-sampling tank is nearly as limited as it is at the input accountability tank--ranging from plus or minus 2 to 5 percent for plutonium concentration at Savannah River. The following example shows the impact these measurement uncertainties have on the effectiveness of the material control and accountability system for the Savannah River reprocessing facility.

Of the 145.5 kilograms of plutonium unaccounted for at the plant (fiscal years 1955-1978), 89.2 were attributed to measurement uncertainties. As with production calculations, this cumulative figure provides only a partial indication of the accountability problems created by measurement uncertainties. The graph on page 18 shows the impact that measurement uncertainties had on plutonium unaccounted for at Savannah River by fiscal year. Although the graph shows recent improvements in measurement capability, yearly unaccounted-for balances of plutonium fluctuated greatly, ranging from shortages of 51.9 kilograms in fiscal year 1964 to overages of 24.1 kilograms in 1957.

A February 1979 DOE safeguards and security assessment report specified the impact that measurement uncertainties had on the effectiveness of Savannah River's material control and accountability system.

> "The current uncertainties (on the order of 2-5 percent) in the input and output accountability measurements for plutonium-239 * * * are so large that the diversion of strategic quantities of plutonium-239 may not be detectable."

In recognition of these uncertainties, DOE Operations Office officials and the facility contractor established control ranges for inventory differences. Based on


ESTIMATE OF PLUTONIUM UNACCOUNTED FOR
FROM MEASUREMENT UNCERTAINTIES
SAVANNAH RIVER REPROCESSING PLANT
FISCAL YEARS 1955-1978
SHORTAGE
OVERAGE
PLUTONIUM (KILOGRAMS)
+60
+50
+40
+30
+20
+10
0
−10
−20
−30
−40
−50
−60
(3.7)
(20.7)
(24.1)
19.0
9.8
42.1
(23.4)
(4.3)
3.7
61.9
8.4
17.3
17.0
(23.6)
8.3
17.3
7.2
(3.2)
(12.7)
4.9
(0.3)
(3.7)
1.8
4.8
55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78
FISCAL YEAR

historical experience, they serve as an alert when inventory differences reach a level that warrants investigation. DOE assumes that material has not been diverted until these control ranges are exceeded. It is not uncommon for significant quantities of plutonium (IAEA's 8 kilograms) to be unaccounted for without exceeding these ranges and yet these differences are assumed to be caused by inaccurate process measurements, production estimates, shipper/receiver measurements, and accounting and normal operating losses.

The inherent lack of accuracy in measuring material at both the front end and the back end of reprocessing operations and the lack of accountability measures throughout the process have led researchers to devise process control systems to monitor solution flow through the facility. Although the primary objective of process monitoring is to provide operational control (i.e., quality control and safety over the process), it may also provide a potential safeguards benefit by detecting large abrupt diversions. For example, process monitors can indicate solution weights, volumes, densities, levels, temperatures, and rates of flow of liquid in the process. A sudden drop in liquid level or a significant change in flow rate could indicate that a diversion is occurring.

In October 1978, a criticality problem at the Idaho Chemical Processing Plant probably could have been avoided if adequate process-monitoring equipment had been in place. During the process, an aluminum nitrate solution is added to assist in the uranium extraction process. If this is not added in the right amount, concentrations of uranium can accumulate and eventually reach a critical state--that point at which a fission chain reaction begins and an explosion can occur due to the rapid expansion and/or vaporization of the solution. During the events leading up to the Idaho incident, a valve failed to close properly, and the uranium concentration momentarily reached criticality in a small pipe. Although no major damage was done, minor amounts of radioactivity were released. DOE and contractor officials told us that an improved process-monitoring system interfaced with a computer system for timely analysis could have detected the increasing concentration of uranium and allowed technicians to shut down the process and repair the faulty valve.

Problems in determining weapons-usable material quantities in wastes

In addition to the lack of accurate measurement capability at the fuel receipt, input accountability, and

product-sampling tanks, accurate measurements are lacking in the radioactive waste portion of reprocessing operations. Although waste streams generally contain only small concentrations of weapons-usable material, the lack of instruments to accurately measure the material leaves open potential diversion paths.

In DOE reprocessing plants, the wastes are collected and sampled in a tank similar to the input accountability tank prior to being transferred to the final waste storage tanks. The average uncertainty of this measurement is about 20 percent, but DOE believes this accuracy is sufficient because of the low concentration of weapons-usable material in the wastes.

In commercial reprocessing facilities, however, wastes contain chopped and empty fuel rods which generally contain less than 1 percent of the material originally in them. Due to the nature of the wastes, commercial facilities would have even more difficulty measuring the weapons-usable material contained in them than does DOE. Consequently, material obtained from other process areas could be stolen by concealing it in cans of waste and recovering it later.

Accountability systems fail to show weapons-usable material quantities in a timely manner

Material control and accountability systems do not provide timely information on quantities of weapons-usable material. If material were diverted, it is doubtful that the diversion could be discovered in time to recover the material before it could be converted into a form suitable for weapons.

As previously stated, an effective material control and accountability system must detect a diversion before the material is converted into a form suitable for weapons. In the case of weapons-usable material from a reprocessing facility, this time frame is from 1 to 3 weeks. Material control and accountability systems used in Federal facilities cannot account for all material and assure that a diversion has not occurred within this time frame. In order to account for material and to provide assurance that a diversion has not occurred, periodic shutdowns and physical inventories of the facility must be conducted. In order to thoroughly account for all material, however, the process must be stopped and all process cells, tanks, and pipes measured and/or chemically flushed to remove as much material as possible. The material recovered during the cleanout would then be

measured and added to the previously accounted for material to provide as complete a physical inventory as possible.

The timeliness of conventional material accounting, therefore, is limited by the frequency of physical inventories. There are practical limits on how often a facility can be shut down for inventory because it is both time consuming and costly. A cleanout inventory takes at least 2 to 4 weeks, and during this time, the facility cannot reprocess. DOE does not require a cleanout, physical inventory at its facilities as it would severely constrain processing schedules. The Idaho Chemical Processing Plant does conduct one after every fuel campaign, which is about every 6 months. The Savannah River reprocessing plant conducts a monthly physical inventory while production is slowed down and its tanks are as near empty as possible. However, this is not a thorough inventory where the tanks and pipes are cleaned out to account for as much plutonium as possible. Savannah River does conduct cleanout inventories after special batches of fuel are processed, which has been six times in the last 5 years. If material were diverted shortly after a physical inventory, however, it could take 6 months or longer to precisely determine the amount of material diverted at Idaho, and even longer at Savannah River. This far exceeds the timeliness goal of from 1 to 3 weeks currently being considered by IAEA.

PHYSICAL SECURITY SYSTEMS CANNOT PREVENT THEFT OF WEAPONS-USABLE MATERIAL

DOE also relies upon physical security to ensure the integrity of its material control and accountability systems. The objective of physical security is to protect weapons-usable material, plant, equipment, and other valuable assets against unauthorized access, use, or removal. The system is intended to interact with the material control and accountability system to provide a mechanism for immediate detection and prevention of attempts to acquire weapons-usable material. Physical security systems being used at Federal reprocessing plants cannot assure that these objectives will be met. Problems exist in the systems which make theft of weapons-usable material possible. DOE recognizes these limitations and is upgrading its systems to improve the effectiveness of physical security at its reprocessing facilities.

Common physical security measures include trained guard forces, barriers, protected buildings, vaults, and

automatic detection devices such as intrusion alarms, doorway monitors, lights, television cameras, and microwave barriers. The system should have a primary and emergency communication network to coordinate the facility guard force and outside law enforcement response forces in the event that a diversion or theft is suspected or occurs.

The Federal Government became concerned about upgrading physical security for plutonium and plutonium-producing facilities around 1972. Since then, DOE has updated standards for physical security and protection of weapons-usable material in 1975 and again in 1979. These standards include the minimum physical security criteria and threat guidance that facility operators must consider in implementing safeguards systems.

In a July 22, 1976, report, 1/ we reviewed the physical security systems at three DOE facilities that handled weapons-usable material. At that time, these facilities had various deficiencies in their physical security systems that reduced their effectiveness. The Savannah River plant was included in this effort.

Many of these deficiencies still exist at Savannah River, and similar problems exist at the Idaho Chemical Processing Plant. Since the specifics of these problems are classified, details are not discussed in this report.

While DOE is currently acting to upgrade the physical security systems at both facilities, we believe and DOE agrees, that until such time that a high priority is placed on upgrading the effectiveness of physical security measures and the upgrades are completed, weapons-usable material will remain potentially vulnerable to theft or diversion.

ACTIONS TAKEN TO UPGRADE SAFEGUARDS AT FEDERAL REPROCESSING FACILITIES

DOE recognizes the limitations of material control and accountability and physical security systems at Federal reprocessing facilities and is acting to upgrade

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1/"Shortcomings in the Systems Used to Control and Protect Highly Dangerous Nuclear Material" (EMD-76-3, July 22, 1976).

safeguards by incorporating non-destructive assay equipment and improved accountability systems in portions of them. The upgrade work, however, will not totally eliminate the risk of material theft or diversion. It is doubtful that the Federal reprocessing facilities could ever be effectively safeguarded DOE officials say as they are old and were not designed with safeguards in mind, material production schedules must be maintained, and existing safeguards technology is limited. While the upgrade work may improve safeguards at these facilities, it is uncertain how much diversion risks will be reduced. DOE has not comprehensively identified these systems' limitations or developed an approach to provide for as much safeguards protection as may be necessary. We believe that until the systems are thoroughly evaluated and a plan for safeguarding material is developed and implemented, weapons-usable material will remain subject to theft or diversion.

In commenting on this report, DOE noted that there will always be some residual risk of diversion because physical security systems cannot preclude all possible modes of theft. DOE agreed that while certain vulnerabilities remain at both reprocessing facilities, these are being addressed as rapidly as possible, consistent with budget and programmatic constraints.

Savannah River reprocessing plant

The need to upgrade safeguards at the Savannah River plant has been recognized since 1972. Specific problem areas have been identified in studies made jointly by Brookhaven National Laboratory's Technical Support Organization, DOE and its predecessor agencies, AEC and the Energy Research and Development Administration, and local Savannah River Operations Office and contractor staffs. DOE, while being aware of the limitations in Savannah River's safeguards system, has not made a concerted effort to upgrade safeguards at the plant.

For example, DOE has not developed a plan to comprehensively identify safeguards needs and actions that could be taken to significantly improve or optimize existing safeguards. As a result, the limited amount of work which is being funded is being done on an ad-hoc basis. According to the Director, Safeguards and Security Division, Savannah River Operations Office, the lack of an adequate number of staff to perform the work prevents him from developing a comprehensive safeguards plan. DOE cannot even produce an estimate of those actions needed, the

amount of funding required, or the time it would take to upgrade safeguards at Savannah River to an acceptable level.

In addition to not developing a comprehensive upgrade plan, DOE has placed a low priority on safeguards upgrade work and funding. Production of weapons-usable material appears to be emphasized, sometimes at the expense of adequate safeguards. For example, although DOE's Operations Office requested upgrade funds for fiscal year 1975, headquarters did not provide funding until fiscal year 1977. Since then, $6.3 million has been authorized for the entire Savannah River complex, of which $3.8 million is being used for upgrading safeguards in the reprocessing facility--$1.3 million for improved material control and accountability, and $2.5 million for physical security.

The upgrade for the reprocessing facility includes the following projects.

Safeguards Upgrade Projects at Savannah River Reprocessing Plant

Project	Cost
Material control and accountability	
Instruments to improve accuracy of plutonium concentration in accountability tanks (upgrade expected to reduce current inaccuracies from plus or minus 2 to 5 percent to 0.2 percent)	$ 130,000
Mass spectrometer for control laboratory to increase current analytic capabilities	590,000
Weighing instruments and neutron well counter for control laboratory to determine plutonium content of samples	300,000
Scrap and plutonium assay equipment (installing permanent measurement capability in an area where portable equipment was previously used)	210,000

Project		Cost
Material control and accountability		
High-Frequency Accounting and Control System (being installed plant-wide to provide for dynamic material accounting system)	a/	80,000
Office space to house personnel and equipment in support of computerized accountability system (plant-wide project)	a/	20,000
Subtotal, material control and accountability		1,330,000
Physical security		
Plutonium vault surveillance system (provide a near-real-time inventory capability)		250,000
Access control and alarm systems in three areas of the reprocessing plant (installation of intrusion alarms, door locks, portal monitors, closed-circuit television, intercoms, and emergency power generation)		2,045,000
Central control and alarm system (project that will interface access control and alarm system of the reprocessing facility to a plant-wide system)	a/	165,000
Subtotal, physical security		2,460,000
TOTAL, REPROCESSING FACILITY UPGRADE COST		$3,790,000

a/Figure represents that portion of the plant-wide project directly related to the reprocessing facility.

A Savannah River Operations Office official estimates that additional work will be required to meet the recommended safeguards level, not only for the reprocessing facility, but also for the entire Savannah River complex. While DOE officials did not know what actions or funding would be

required for the reprocessing portion, it is believed that such improvements would include additional alarms, closed-circuit televisions and other monitoring devices, non-destructive assay equipment, and a near-real-time computerized data system.

In commenting on this report, DOE noted that its budget is limited, and there is a need to balance national security concerns and costs associated with both materials production and safeguards. While DOE agreed that more needs to be done to improve security at Savannah River, the decisions on the allocation of fiscal resources have been made with a view towards these concerns.

Idaho Chemical Processing Plant

The upgrade program at the Idaho Chemical Processing Plant has been developed over a period of years in response to changing safeguards regulations. In contrast to Savannah River, an upgrade plan was developed based on the results of a contractor's task force study, DOE assessment reviews, and compliance with revised DOE safeguards and security regulations. A DOE Operations Office official said that this plan identifies the major safeguards weaknesses at the Idaho facility and specific projects to correct these weaknesses. The plan, however, does not comprehensively identify the limitations of the safeguards and security system or those actions that could be taken to optimize safeguards at the Idaho facility.

Current and planned upgrade work will provide for increased physical protection and improved material control and accountability. Total funds approved from fiscal year 1977 through 1980 amount to $2.8 million, of which 80 percent will be for physical security and 20 percent for material control and accountability.

The initial thrust of the upgrade consists of a three-phase, $2.3 million upgrade of the physical security system. Phase I work, which was completed by the end of fiscal year 1978, cost $194,000. Improvements made consist of

--procurement and installation of four closed-circuit TV systems for sensitive areas,

--installation of hardened doors and a perimeter fence around the unirradiated fuel storage building,

--procurement of a special nuclear material detector and a metal detector for field testing,

--installation of intercom systems to the unirradiated fuel storage building and the vault-denitrator material access areas, and

--installation of a dedicated conduit/cable for security alarms and card access systems.

Phase II work, which was completed in September 1979, cost $1.3 million. Improvements made consist of

--design and construction of a new guardhouse to provide a hardened centralized communications and alarm center with portal monitors and surveillance equipment,

--construction of security barriers for material access areas,

--installation of improved perimeter lighting and intrusion alarm systems, and

--construction of vehicle entrance and bus parking facilities.

Phase III work, which is near completion, is costing $800,000. Improvements being made consist of

--design, procurement, and installation of a safeguards and security data collection and processing system;

--procurement and installation of portal monitoring and explosive detection equipment; and

--construction of a perimeter barrier fence.

In order to improve the adequacy of measurement capability in the process, a $525,000 upgrade project is being done to install an additional material balance area between the end of the solvent extraction process and the start of the denitrification process. This project will enable the facility operators to determine the input quantity of solution to the denitrification process, a function which cannot currently be performed. The project is anticipated to be completed by September 1980.

Facility contractors are hopeful these modifications will significantly improve the timeliness of potential diversion detection but anticipate that additional upgrade work will be needed. The DOE contractor is planning to

request $3.3 million for fiscal year 1982 to upgrade the plant perimeter system. This project would provide an extended protected area perimeter security fence, additional perimeter lighting, back-up alarm systems, closed-circuit TV assessment capability, new patrol roads, an external construction access road, explosive monitors, and an automatic-vehicle special nuclear material monitor.

The DOE contractor has also requested $912,000 for fiscal year 1981 to plan and design an estimated $6.5-million project to rennovate the process cells. This subproject is part of a larger project directed to improve the safety and operation of the process by adding shielding barriers, process-monitoring equipment, and data collection and processing devices in the process building. The $6.5-million project would directly benefit the material control and accountability safeguards system by providing additional measurement capability in the portion of the process that experienced the criticality problem in October 1978. The project would not only assist in avoiding a future criticality problem, but would also provide additional measurement capability within the process where no such capability existed before.

CONCLUSION

Material control and accountability and physical security systems used by DOE at Federal reprocessing facilities cannot assure the timely detection of diversions of weapons-usable material by subnationalist groups or individuals. Since fiscal year 1955, a net shortage of 145.5 kilograms of plutonium occurred at the Savannah River reprocessing plant. DOE is unable to provide definitive assurance that no plutonium has been diverted.

DOE has been aware of the limitations of safeguards systems at Federal reprocessing facilities for many years and is acting to upgrade them. Although the upgrades may improve the adequacy of the safeguards systems, we believe DOE could do more to optimize the level of safeguards afforded at these facilities. Current upgrade work, particularly at Savannah River, lacks a plan which comprehensively identifies safeguards needs and actions that could be taken to optimize the safeguards systems. In addition, DOE has placed a low priority on safeguards upgrade work and funding. Until comprehensive safeguards plans are developed and their implementation becomes a priority, we believe that weapons-usable material will remain subject to possible diversion by subnationalist groups and individuals. In commenting on this report, DOE stated that

there will always be some risk of diversion from its reprocessing facilities irrespective of safeguards planning. DOE believes, however, that the combination of physical protection and material control provides adequate levels of assurance against the subnational diversion threat.

RECOMMENDATION TO THE SECRETARY OF ENERGY

The Secretary, Department of Energy, should develop comprehensive plans for the Federal reprocessing facilities which identify problems of safeguarding material in these facilities and determine actions that could be taken to develop and implement integrated safeguards systems.

CHAPTER 3

EFFECTIVE INTERNATIONAL SAFEGUARDS FOR THE PRODUCTION, STORAGE, AND USE OF PLUTONIUM ARE LACKING

The administration's policy of indefinitely deferring commercial reprocessing of nuclear fuel had limited impact on the reprocessing programs and plans of other nations. Nine other nations have reprocessed spent fuel or are developing plans to do so. Current INFCE estimates are that 25 tonnes of separated plutonium exist worldwide, and by the year 2000, this will increase to about 885 tonnes.

The large amounts of separated plutonium that exist and that will be produced worldwide reinforces the need for (1) effective international safeguards to detect diversions and (2) effective international control over the subsequent storage and use of the separated material. To date, such effective systems and controls are nonexistent.

IAEA has no experience safeguarding commercial-size reprocessing facilities and believes that existing international safeguards are so limited that it could not quickly detect diversions of significant quantities of material if these facilities were currently operating. In addition, there is no international system to control the storage and subsequent use of separated plutonium. Until effective international safeguards systems for reprocessing facilities and effective international controls over the storage and subsequent use of separated plutonium are developed and implemented, commercial reprocessing and recycling of nuclear fuel will remain a high proliferation risk and a threat to world peace and stability.

IN SPITE OF U.S. POLICY, WORLDWIDE NUCLEAR FUEL REPROCESSING INDUSTRY CONTINUES TO GROW

The U.S. indefinite deferral of commercial reprocessing and the establishment of the INFCE program have made other nations more aware of the proliferation risks of reprocessing. However, these efforts have had limited effect at changing the long-term plans of many nations to reprocess spent fuel from their own nuclear reactors and/or other nations. France and the United Kingdom have already contracted to provide reprocessing services for West Germany, Japan, and The Netherlands.

Nations participating in INFCE appear to recognize the proliferation risks of reprocessing. However, some nations foresee a need for, and anticipate appreciable economic and political benefits of reprocessing which, in their view, could outweigh any potential for increased proliferation. Indications from INFCE show that many nations maintain that no fuel cycle should be avoided solely on proliferation grounds if there are good and prudent economic and energy-strategic arguments in favor of introducing it on an industrial scale.

The table on page 32 lists commercial reprocessing facilities operating and planned in other nations. As the table indicates, nine countries either are operating or are planning to operate facilities to reprocess light water reactor spent fuel. Indications are that commercial reprocessing will play an important role in the future energy programs of at least the larger nuclear energy-producing nations. DOE believes, however, that there are considerable uncertainties about the future of commercial reprocessing.

The economic and strategic arguments made in favor of commercial reprocessing are highly debatable and differ from country to country. The economic arguments depend not only on the price of uranium, the costs of reprocessing and waste disposal, but in particular, on the subsequent use made of the separated plutonium and uranium.

If plutonium is recycled in light water reactors, the economic advantage of reprocessing is not likely to be large, although some countries view the advantage as being greater than others, depending on the need for and contribution it makes toward energy independence and assurances of fuel supply. INFCE calculates that uranium savings of up to 40 percent are achievable from uranium and plutonium recycling compared with the once-through cycle in light water reactors on the basis of present technology.

Since the administration is attempting to discourage early commercialization of breeder reactors, and it is believed that the United States has adequate supplies of fuel resources for an extended period of time, the administration views the benefits associated with reprocessing to be marginal. With increased fuel burnup, DOE estimates that uranium ore concentrates would have to cost well over $100 per pound before reprocessing would be economical. (The current price is about $45 per pound.) Countries which are virtually dependent on imports to meet their energy needs, such as Japan and Belgium, assign a higher value to the benefits of reprocessing. Japan believes the break even point is anywhere above $35 per pound, and Belgium believes it is about

Current Operating and Planned Commercial Reprocessing Services for Uranium Oxide Fuel

Country	Number of facilities	Design capacity (tonnes/year)	Status
Belgium	1	75	Shut down 1974. Possible start-up with a 300 tonne/year expansion.
Brazil	1	(a)	Operation planned for mid to late 1980.
France	2	800 1,600	1976 start-up. Planned for mid 1980s.
India	1	100	Operational.
Italy	2	10 500	Operational. Being considered for 1985.
Japan	2	200 1,500	Operational. Planned 1990.
Sweden	1	500-800	Under consideration for mid 1990s.
United Kingdom	2	300 1,000	Shut down in 1973. Planned for 1987.
West Germany	2	40 1,500	Operational. Originally planned for 1985 to 1990 but indefinitely postponed.

a/Pilot.

$25 to $35 per pound. At this point, it seems inevitable that countries with little or no indigenous uranium supplies and without alternative means of meeting their foreseen future energy needs will look favorably at the reprocessing and recycle option.

While some nations foresee economic benefits of recycling the plutonium back into light water reactors in the near term, others anticipate the need for reprocessing to prepare for breeder reactors. Some nations feel these will be practical and economical within the first decade of the 21st century. Breeders require plutonium as part of their fuel, can produce more fuel than they consume during fuel burn-up, and provide fuel for additional reactors. Many countries believe that breeders will play a significant role in meeting their increasing energy demands and attaining a greater degree of energy independence. Breeder technology requires reprocessing of spent fuel discharged from currently operating reactors and of fuel discharged from breeder reactors. The United Kingdom, France, and West Germany are already operating pilot reprocessing facilities for breeder-type fuels in anticipation of breeder reactor commercialization.

Aside from economics, some nations require reprocessing or other disposal arrangements in order to license new nuclear reactors. For example, Japan guarantees local citizens that spent fuel will not be stored at reactor sites. It believes that reprocessing is the best way to handle the spent fuel and avoid a spent fuel storage problem. As a result, Japan has shipped spent fuel to France and the United Kingdom for reprocessing, and anticipates handling the remainder of its own reprocessing requirements by 1990.

Another position presented by some nations in support of reprocessing is that storing weapons-usable material indefinitely in spent fuel poses an even greater proliferation risk than reprocessing the spent fuel. For example, Belgium sees reprocessing and the recycling of plutonium as the safest way to guard weapons-usable material, because the plutonium is burned to produce power.

Although the administration had hoped that other countries would defer commercial reprocessing, results of INFCE and the plans of many nations indicate that the industry will grow. As a result, effective safeguards at the international level will be required to assure that diversions of weapons-usable material--whether contained in spent fuel, reprocessed form, or mixed fuel form--are detected.

INTERNATIONAL SAFEGUARDS LIMITED FOR DETECTING DIVERSIONS FROM COMMERCIAL-SIZE REPROCESSING FACILITIES

IAEA will have difficulty assuring the international community that a nation operating a commercial reprocessing facility is not diverting material for weapons purposes. IAEA has no experience in safeguarding commercial-size reprocessing facilities and believes that the limitations of existing international safeguards would prohibit it from detecting material diversions of significant quantities in a timely manner if these facilities were currently operating.

The major limitations of international safeguards are that

--technical limitations of material control and accountability systems prevent IAEA from independently detecting and verifying material diversions by host nations in a timely manner and

--containment and surveillance systems are not reliable for assuring the integrity of material control and accountability systems.

IAEA recognizes these limitations and has established an international working group to comprehensively study safeguards systems and techniques for reprocessing facilities.

International safeguards, administered by IAEA, are intended to (1) detect diversions of significant quantities of nuclear material in a timely manner from peaceful nuclear activities and (2) deter such diversions by the risk of early detection. Whereas domestic safeguards systems are directed toward preventing diversions by subnationalist or terrorist groups, international safeguards are aimed at detecting covert diversions by nations. Therefore, IAEA views the host nation as a potential adversary.

IAEA safeguards are developed on the basis of verification of nuclear material accountability and the use of containment and surveillance. IAEA considers material control and accountability as the fundamental safeguards measure. Containment and surveillance is used to reinforce the assurance obtained from material accountability.

IAEA has had limited experience safeguarding reprocessing facilities. Since 1976, it has continuously inspected

only four reprocessing plants, all of which are considered to be small or pilot facilities. IAEA also inspects a fifth facility, but the inspection is limited to the spent fuel storage area.

The largest facility IAEA has inspected is the Tokai facility in Japan. This facility has a design capacity of 200 tonnes per year, 1/ but has not yet operated at this level. Since 1977, the facility has conducted five "hot" tests, during which 30 tonnes of fuel were reprocessed.

IAEA's experience with small facilities indicates that despite a number of practical problems, material accountability supplemented by containment and surveillance measures may be capable of providing effective international safeguards in small-scale facilities. IAEA has concluded, however, that present safeguards would not be adequate for future, commercial-size facilities because the accountability and timeliness requirement for detecting 8 kilograms of plutonium in 1 to 3 weeks cannot be met.

IAEA faces the same technical limitations in material control and accountability systems as are found in the U.S. safeguards systems--measurement uncertainties and timeliness problems. As indicated in chapter 2, operating facilities in the United States experience measurement uncertainties as large as plus or minus 10 percent. Even with state-of-the-art safeguards technology and proper planning in the design of the facility, researchers predict the ability to measure material flows and inventories could still be subject to uncertainties of plus or minus 0.5 to 1.0 percent. In large, commercial-size plants these measurement uncertainties could result in as much as 150 kilograms of plutonium being unaccounted for per year which could lead to an inability to assure whether or not a significant diversion had occurred.

The detection time criteria also poses a problem. Determining whether material has been diverted using existing material accountability requires periodic facility shutdowns and clean-outs. Desired sensitivity and timeliness could be obtained if drain-down, flush-out physical inventories were taken daily or weekly, but this would so severely interrupt normal processing that operating the facility would become infeasible.

1/The base-case commercial-size reprocessing plant is generally considered to have a design capacity of 1,500 tonnes per year. Such a facility would be capable of reprocessing the spent fuel discharged from about 50 large power reactors per year.

These limitations have led IAEA to conclude that a different approach is required to safeguard large reprocessing plants. Plant operators have been working on a number of new systems to be incorporated into the design of future plants which would hopefully enable future facilities to meet IAEA guidelines. These systems may be categorized as

--improved containment and surveillance techniques and

--modified or in-process material accountability.

IAEA relies on containment and surveillance as an important supplementary measure to material control and accountability. Its purpose is to ensure, through a combination of physical barriers, seals, optical and instrumental surveillance devices, and the physical presence of IAEA inspectors, an acceptably high probability of detecting the removal of material. The advantages of containment and surveillance are that, unlike material accountability, they are largely independent of the actions of the operator, and provide a timely alarm of a possible diversion without the need for process interruption. Whereas containment and surveillance systems cannot, by themselves, detect and verify diversions because they do not quantify material flows, they should perform three important functions. Containment and surveillance should (1) help to maintain the integrity of material accountability data by ensuring that all material flows by key measurement points, (2) indicate tampering with safeguards equipment, and (3) indicate unusual process-operating conditions.

The ability of containment and surveillance to increase the effectiveness of international safeguards, however, relies heavily on the

--identification of all credible paths for diversion of material;

--degree of redundancy and replication in its application to ensure that failure and false alarm rates do not result in unacceptable burdens on facility operators and/or inspectors;

--timeliness of containment and surveillance measures, which requires either automatic data recording and alarm systems or a heavy IAEA inspection commitment to attain adequate timeliness; and

--procedures to establish whether a significant quantity of material is missing if and when a containment and surveillance barrier has been penetrated.

Reliable containment and surveillance systems have not yet been developed for reprocessing facilities to the degree necessary to meet IAEA's needs. For example, a number of seals used by the IAEA do not provide assurances against substitution, or must be scanned at headquarters to ensure their integrity. Much of the optical surveillance equipment is still too costly, requiring a high degree of expert maintenance. In addition, monitoring devices which are sensitive enough to more effectively and reliably detect movements of material have yet to be developed. Until technological improvements in containment and surveillance devices can be demonstrated and evaluated, a heavy IAEA physical inspection effort will be required.

Along with the use of improved containment and surveillance, IAEA is anticipating the use of in-process material accountability to improve the sensitivity and timeliness of conventional material control and accountability. In this type of system, inventories would be taken "in process" so as not to interrupt normal operations. It may also be possible to use some of the operator's own process-monitoring sensors, supplemented by additional sensors installed for safeguards purposes, to look for unusual process activities. While insufficient in themselves to determine if and when a diversion is occurring, unusual activities may be a necessary part of a diversion effort. A combination of this "dynamic process monitoring," with some form of computerized "dynamic materials accountability," could provide significant improvements in detection sensitivity and timeliness, and reduce the possibility of false alarms. The status of these concepts as a safeguards measure is still relatively new. However, IAEA feels that given considerable development and demonstration, they have the potential for implementation at a reasonable cost.

An international working group, established by IAEA in November 1978, is currently involved in a 2-year effort to comprehensively study safeguards systems and techniques for reprocessing facilities. The objectives of the study are to improve the cost effectiveness of such safeguards, and develop a methodology to assess various combinations of techniques. The scope of the working group's effort includes:

--developing a means for quantifying to the extent possible, the assurances given by material accountability and containment and surveillance techniques;

--analyzing the degree to which alternative safeguards approaches would meet IAEA objectives and criteria;

--developing verification procedures for taking physical inventory and closing out material balances;

--developing safeguards techniques and approaches to enable IAEA to maintain continuity of knowledge of the flow and inventory of nuclear material during intervals between clean-out physical inventories;

--examining the cost effectiveness of various safeguards strategies, approaches, and techniques;

--designing optimum safeguards strategies and approaches for reprocessing facilities;

--examining the applicability of safeguards approaches developed for small- or medium-sized facilities to large facilities, and developing adaptations or new approaches where necessary;

--demonstrating the validity of developed safeguards concepts; and

--establishing priorities for developing different safeguards methods and techniques.

INTERNATIONAL CONTROL OVER SEPARATED PLUTONIUM IS LACKING

In light of the number of nations reprocessing or planning to reprocess, excess stocks of plutonium are expected worldwide. To reduce the proliferation risks created by scattered plutonium stockpiles, an international control system is needed for excess plutonium. Such a system does not exist, and partly because of the administration's policy on reprocessing the United States is throwing less than its full weight behind the proposed international plutonium management and storage regime.

International plutonium storage concept

Participants in INFCE estimate that plutonium contained in spent fuel already amounts to approximately 100 tonnes, of which some 25 tonnes have been separated. They also estimate that by 1985, about 48,000 tonnes of spent fuel will have been discharged by nuclear reactors. By the year 2000, this figure is expected to increase to 226,300 tonnes. Between two-thirds and three-fourths of the spent fuel expected in storage will originate in North America--about 22,000 tonnes by 1985, and 108,000 tonnes by the year 2000 within the United States alone. Outside of North America, countries expect to reprocess approximately 9,000 tonnes by 1985, and nearly 100,000 tonnes by the year 2000. By 1985, this will result in about 117 tonnes of separated plutonium, and by the year 2000, this figure will increase to about 885 tonnes.

INFCE projects that for at least two decades, plutonium production will exceed the amount needed to meet energy demands. In certain cases, separation of plutonium before it is needed is likely to entail proliferation risks arising from the spread of scattered plutonium stockpiles. This could increase the danger of the further proliferation of nuclear weapons. In order to reduce the existing danger posed by stockpiles, and the increasing risks posed by future plutonium stockpiling, there is a need for effective international control and management of the material.

The fundamental objectives of international plutonium management would be to

--prevent national stockpiling of plutonium in participating states and thus reduce the danger of the production of plutonium-based nuclear weapons or other nuclear explosive devices by placing stocks of plutonium in internationally controlled storage,

--obviate the need for such stockpiling by ensuring supplies of plutonium to participating states for specified needs in reactors or for research, and

--lessen the possibility of seizure/theft of plutonium by subnational or terrorist groups.

In spite of the need for controlling the storage and use of separated plutonium stocks, such a system does not exist.

With respect to reprocessing facilities under IAEA safeguards, IAEA has the authority to require the deposit with it of certain excess plutonium in order to prevent stockpiling. This authorization is contained in Article XII.A.5 of IAEA's Statute within the context of its safeguards rights and responsibilities. The relevant section of paragraph A.5 reads as follows:

> "* * * to require that special fissionable materials [i.e., plutonium] recovered or produced as a by-product be used for peaceful purposes under continuing Agency safeguards for research or in reactors, existing or under construction, specified by the member or members concerned; and to require deposit with the Agency of any excess of any special fissionable materials recovered or produced as a by-product over what is needed for the above-stated uses in order to prevent stockpiling of these materials, provided that thereafter at the request of the member or members concerned special fissionable materials so deposited with the Agency shall be returned promptly to the member or members concerned for use under the same provisions as stated above."

IAEA has never exercised this authority, however. IAEA has no enforcement mechanism to obtain plutonium and thus relies on voluntary participation by member nations. Member nations appear unwilling to submit to IAEA's authority until consensus is reached on the specifics of how the international plutonium storage system will operate. The major problems currently prohibiting such a scheme include

- --devising a system that is adequately "proliferation resistant" to minimize the risk of forcible seizure of international plutonium stores;

- --establishing sufficiently strict rules for the release of plutonium from stores to prevent the stockpiling of plutonium or the diversion of plutonium for military use by recipient nations; and

- --ensuring that the system is sufficiently flexible to allow that legitimate plutonium requirements are promptly met in a non-discriminatory manner.

In December 1978, IAEA initiated an effort to examine the (1) location of stores, (2) form in which plutonium should be stored, (3) management and operation of stores, (4) conditions which should be attached to plutonium release, (5) legal basis for the system, (6) form the system's

controlling body should take, and (7) powers the controlling body should have.

Over 20 countries are participating in the International Plutonium Storage Expert Group, including the United States. The Group is to report to IAEA's Board of Governors its recommendation on how to implement such a storage regime. This effort is expected to take at least 2 years depending on how quickly and satisfactorily participating nations' concerns can be incorporated into the Group's report to IAEA.

U.S. non-proliferation policies may be hampering efforts to reach consensus

The Nuclear Non-Proliferation Act of 1978 (P.L. 95-242) authorizes the President to seek negotiations, as soon as practicable, with nations possessing nuclear fuel production facilities or source material, and with other nations and groups of nations, such as IAEA, with a view towards the timely establishment of binding international undertakings providing for

> "* * * feasible and environmentally sound approaches for the siting, development, and management under effective international auspices and inspection of facilities for the provision of nuclear fuel services, including the storage of [plutonium]."

The act also authorizes the President to obtain other nations' commitment to reprocessing under international auspices.

The United States subsequently joined IAEA's International Plutonium Storage Expert Group. In stressing its non-proliferation concerns over the concerns of other participants, however, the United States could be unduly delaying the establishment of a regime.

During its participation in the Expert Group, the United States has raised concerns regarding (1) premature separation of plutonium, (2) the need for vigorous non-proliferation controls as a part of any plutonium management regime, and (3) the growing requirements for additional worldwide spent fuel storage. The United States is also urging that any study of an international plutonium management regime cover the entire period from plutonium production in a reprocessing plant to reirradiation in a reactor or use in research.

Some nations participating in the IAEA Expert Group express concern that the U.S. preference for international

spent fuel storage has lessened its commitment to organizing an international plutonium storage regime. They say that U.S. policy makers fear that supporting the international plutonium storage proposal would undercut the U.S. international spent fuel storage plan and would be perceived as a change in the U.S. position regarding the legitimacy of reprocessing.

Officials from DOE expressed doubts whether an international plutonium storage regime would even be an effective tool for reducing proliferation risks. ACDA officials agree that such a concept is desirable, but are concerned that the regime be organized to effectively control plutonium storage and its subsequent use. The Department of State believes that an international plutonium storage regime will not solve proliferation problems unless it is established in a manner that can effectively control the international storage and use of separated plutonium. Many U.S. officials are also concerned that U.S. endorsement of such a regime would lead to premature reprocessing and would circumvent current U.S. controls (bilateral agreements) over U.S.-supplied nuclear fuel and its ultimate disposition. The United States prefers, instead, to stress the importance of international spent fuel storage and the strengthening of its bilateral agreements with other nations.

The United States, which traditionally has been a leader both in the nuclear field and in initiating international cooperative agreements, appears to be throwing less than its full weight behind the proposed international plutonium management and storage regime. In commenting on the ability to reach agreement on arrangements for international custody of commercial plutonium, a November 1978 study by the International Consultative Group on Nuclear Energy notes that:

> "Especially difficult problems are raised by efforts of some suppliers to retain the right to approve any disposition or treatment of spent fuel discharged from power reactors in recipient countries, even though the supplier is under no obligation to accept the return of such spent fuel if no other disposition is mutually acceptable * * *. Additional restraints in bilateral agreements are at best only a partial solution.
>
> Some suppliers insist on conditions which are more onerous than are required by others. The absence of uniformity not only tends to distort international trade patterns in nuclear materials, services and equipment, but also may subject nuclear enterprises in recipient countries to conflicting conditions when

several sources of supply are involved. Restrictions are most likely to be accepted where they are least needed."

In commenting on this report, the Department of State, ACDA, and DOE officials generally agree on the need for international plutonium storage. ACDA officials believe, however, that we are incorrect in stating that the United States has less than its full weight behind the proposed international plutonium storage regime. DOE and State Department officials said it would be both illogical and imprudent for the United States to throw its full weight behind a system which has yet to be defined. They say the United States is actively and constructively participating in the IAEA Expert Group to seek to assure that the international plutonium storage regime is as effective and credible a non-proliferation regime as possible. Only when the proposed system is defined will the United States be in a position to determine whether and under what conditions it would be prepared to support such a system. Until such time, the U.S. approach will be one of agnosticism.

CONCLUSION

U.S. efforts to defer worldwide commercial reprocessing and the premature separation of plutonium are having only limited success. In spite of the administration's policy, many countries are reprocessing or continue plans to develop commercial reprocessing industries. Recognizing these plans and the resulting excess plutonium that may be produced, effective international safeguards and controls over the production, storage and use of separated plutonium are needed. No such systems currently exist.

Current international safeguards systems do not appear capable of detecting diversions of significant quantities of plutonium from planned, commercial-size reprocessing facilities. An international mechanism is lacking to control the storage and use of separated plutonium. Without effective international safeguards and controls, reprocessing and the subsequent use of separated plutonium will pose significant risks to world peace and stability.

Although the United States is participating in international efforts to improve safeguards systems and to establish an international plutonium storage regime, we believe the United States could and should be making a more concerted effort to develop and demonstrate effective safeguards technology (see ch. 4), and to establish an effective international plutonium storage system. We also believe that the current amounts of separated plutonium (25 tonnes) and the

projections of future stocks (885 tonnes by the year 2000) underline the importance of establishing such a system promptly.

RECOMMENDATION TO THE SECRETARY OF STATE

The Secretary of State should intensify the Department's efforts to establish, in conjunction with the major nuclear users, suppliers, and reprocessors, a system to control the storage and use of existing and future international stocks of separated plutonium. This effort could be in conjunction with, or in lieu of, the international plutonium storage regime being studied by IAEA.

CHAPTER 4

U.S. RESEARCH AND DEVELOPMENT EFFORTS LACK COMPREHENSIVE APPROACH FOR SOLVING REPROCESSING SAFEGUARDS PROBLEMS

U.S. research and development efforts to improve the effectiveness of safeguards for operating reprocessing facilities within the United States and in support of international safeguards, falls short of providing the framework needed to solve reprocessing safeguards problems.

--Deferral of commercial reprocessing within the United States has deemphasized reprocessing safeguards research and development efforts.

--Current reprocessing safeguards research and development efforts lack direction and control.

DEFERRAL OF COMMERCIAL REPROCESSING WITHIN THE UNITED STATES HAS DEEMPHASIZED REPROCESSING SAFEGUARDS RESEARCH AND DEVELOPMENT

The administration's policy which called for an indefinite deferral of commercial reprocessing also called for a redirection of research efforts aimed at developing a more proliferation resistant fuel cycle. DOE subsequently redirected its safeguards research work away from reprocessing facilities, and concentrated its efforts in other areas of the nuclear fuel cycle and in alternative fuel cycles. To date, results from the U.S. Non-proliferation Alternatives Systems Assessment Program and INFCE indicate that none of these nuclear fuel cycle alternatives appear to significantly reduce the risk of a nation's diverting material for weapons purposes. 1/ In addition, the redirection appears to have deemphasized U.S. efforts to develop effective safeguards systems for both its own and commercial facilities subject to international safeguards.

1/This conclusion has also been presented in reports issued by GAO ("Nuclear Reactor Options to Reduce the Risk of Proliferation and to Succeed Current Light Water Reactor Technology," EMD-79-15, May 23, 1979) and by the Congressional Research Service ("Alternative Breeding Cycles For Nuclear Power: and Analysis," House Science and Technology Committee, October 1978).

As shown in chapter 2, major domestic safeguards limitations are due to the technical inability to accurately measure (1) plutonium content in spent fuel, (2) weapons-usable material in process, and (3) material contained in waste streams. The lack of adequate material control and accountability technology and equipment, coupled with unreliable containment and surveillance devices, severely constrains the development of effective international safeguards. Only limited research and development effort is being expended in these problem areas, and little more is currently planned.

DOE's Office of Safeguards and Security (OSS) has primary responsibility for conducting research and development aimed at the design, implementation, and operation of effective safeguards and security components and systems. It serves as a liaison in providing support to private industry, the Nuclear Regulatory Commission, the international community, and IAEA. Its total budget in the safeguards area has been about $39 million each year since fiscal year 1977. The table on page 47 indicates the limited effort DOE is expending to improve the effectiveness of domestic and international safeguards systems for spent fuel reprocessing.

Since the indefinite deferral policy took effect, it appears that OSS has deemphasized research specifically directed at improving safeguards for reprocessing facilities. We attempted but were unable to determine the specific impact the deferral policy had on this effort, because OSS could not provide us a breakdown of funds expended for reprocessing safeguards research and development from fiscal years 1976 through 1978. According to one OSS official, however, the policy resulted in some cancelled projects while others were delayed or relegated to "paper studies." While OSS was specifically directed not to conduct additional safeguards research for commercial reprocessing, some projects are being done under the category of "nuclear fuel cycle facilities," the results of which will only be partially applicable to reprocessing plants. As the table indicates, DOE expended less than $3 million in fiscal year 1979 to conduct research and development to improve domestic and international safeguards systems. No funds were expended to develop instruments to improve the accuracy of input and product measurements or to measure the plutonium content of waste streams. In addition, only minor expenditures ($70,000) were made to develop instruments to determine the plutonium content of spent fuel. As the table also indicates, DOE is not anticipating any substantial increase of expenditures in these areas for the next 2 fiscal years.

DOE/OSS Research and Development Funding for Spent Fuel Reprocessing

	Operating funds		
	FY 1979	FY 1980	FY 1981
	(thousands)		
Domestic			
Physical Protection			
a. Improving protection at reprocessing facilities	$ 500	$ 220	$ 600
Material Control and Accountability (partially applicable to international safeguards)			
a. Pu content of spent fuel	70	0	0
b. Improving accuracy of input and product measurements	0	0	0
c. Improving timeliness of material control and accountability	1,625	1,760	1,700
d. Pu content of waste streams	0	200	200
	2,195	2,180	2,500
International			
a. Improving the capability of IAEA to independently verify information and inventories (other tasks included in Program of Technical Assistance to IAEA Safeguards funded separately by Department of State)	150	100	150
b. Increasing reliability of containment and surveillance devices (including tamper-proofing)	150	175	280
c. Conceptual applicability of safeguards measures, IAEA Working Group, and technology transfer	500	730	800
	800	1,005	1,230
TOTAL RESEARCH AND DEVELOPMENT FUNDING FOR SPENT FUEL REPROCESSING	$2,995	$3,185	$3,730

As a result of the policy, in September 1978 DOE cancelled a research program at one laboratory which focused on material accountability instrumentation for light water reactor spent fuel reprocessing, and the development of instruments and techniques for safeguarding weapons-usable material in breeder reactor spent fuel reprocessing facilities. The Safeguards Program Director for the DOE laboratory said that the projected budget for this program was $1.63 million through fiscal year 1984. Funding for flow meters and process control equipment research, development and demonstration has also been reduced, resulting in the deferral of important and necessary research on at least two process-monitoring devices. Los Alamos Scientific Laboratory, one of the leading laboratories in developing integrated safeguards concepts and systems, believes that its research and development efforts have been set back as much as a year because of the President's policy and lack of funding. The Idaho Chemical Processing Plant may have to cut back its international safeguards staff by two people, and Sandia officials estimate that the policy has caused a 20-month delay in its study of physical security requirements for reprocessing facilities.

Not only has the deferral policy cut back or delayed work previously planned or being conducted, researchers are limited in the degree to which they can develop and test advanced reprocessing safeguards concepts. One example of an advanced safeguards concept which has not been demonstrated in an operating reprocessing plant is the near-real-time accounting system. Such a system could, theoretically, provide inventory balances as often as practicable--perhaps every 15 minutes if desired--and thus reduce both the period between inventory balances, as well as the margin for error in the measurements. A near-real-time system would combine new measurement instruments and methods with computerized measurement controls and sophisticated data analysis techniques. A reprocessing facility would ideally be subdivided into smaller measurement and accountability areas controlled by computer. The instruments would then continuously monitor material flow in and out of areas, and send measurements to a computer. In this way, material balances could be drawn more frequently around quantities of material much smaller than the total plant inventory. While IAEA has concluded that considerable development and demonstration effort for near-real-time accountability is needed, studies indicate that it could be feasible to install the system in portions of a facility.

Researchers at the Los Alamos Scientific Laboratory predict that in the plutonium purification process area of a large chemical reprocessing plant, diversion sensitivities

of from hours to a few weeks could be achieved for small trickle diversions. While these are only predictions, they would be a significant improvement over the current capability of significant quantities every 6 months. Researchers are hopeful that these sensitivities can be achieved at a reasonable cost and with minor improvements to state-of-the-art technology.

OSS officials say the lack of an operational reprocessing facility, however, has had adverse impacts on its ability to pursue the effectiveness of this concept as an advanced safeguards measure. Whereas near-real-time is being evaluated in a portion of the Los Alamos plutonium fabrication facility, it does not have the operating characteristics nor hostile radioactive environment that a reprocessing facility has. In addition, this facility is quite small, thus making it difficult to apply results to large facilities. A convincing demonstration of the usefulness of this accountability system would require a full-scale evaluation in a large operating plant.

We believe that the two Federal reprocessing facilities could be used to demonstrate, in part, the feasibility of the Los Alamos near-real-time accountability concept. In light of the timeliness problems that these facilities are experiencing in their accountability systems (see ch. 2), such a demonstration would not only improve the effectiveness of the safeguards at these facilities, but would also advance the near-real-time concept for commercial and international application.

Other DOE programs to develop and test advanced reprocessing safeguards concepts were also adversely affected by the deferral policy. In September 1978, DOE terminated its Converter Fuel Program at Savannah River Laboratory. The objective of this program was to develop and demonstrate reprocessing technology for light water reactor converters with special emphasis on thorium fuel. The program would have benefited the safeguardability of future, commercial-size reprocessing facilities by improving the facility design to provide for more remote operation and monitoring of material flows. Whereas researchers were able to complete the conceptual design for the advanced facility, DOE discontinued funding the program so that the demonstration facility could not be constructed.

In fiscal year 1979 DOE organized the Advanced Fuel Recycle Program. Under the technical leadership of the Oak Ridge National Laboratory, the program is attempting to develop and demonstrate alternative and innovative systems designs and operating techniques for advanced reprocessing facilities. These designs are directed at

increasing the proliferation resistance of vulnerable operations and key process equipment. The program manager estimates the operating costs of this program to be $400 million through fiscal year 1990. These funds plus an additional $900 million will be needed to design and construct a fully operational demonstration facility by 1991. The program manager says the deferral policy is adversely affecting this program because it is creating uncertainty about the program's future mission. For example, although the conceptual design for this facility is expected to be complete by March 1981, the program manager fears that, like the Converter Fuel Program, DOE will terminate the program before the technology can be demonstrated. If this occurred, the DOE official said that not only would efforts to improve safeguards be set back, but also that much technical expertise in the reprocessing area would be lost.

Selected safeguards research and development activities are also being carried out at the partially completed Allied General Nuclear Services facility at Barnwell, South Carolina. However, because of the 1977 policy the Congress is authorizing funds only for research which would not lead toward the facility's commencing reprocessing operations. In fiscal years 1978 and 1979, research was sponsored for (1) spent fuel transportation, handling, and storage; (2) development and testing of an advanced integrated safeguards system for fuel cycle facilities; and (3) development of proliferation-resistant alternative fuel cycles adaptable to commercial ventures. Although some work is useful and applicable to reprocessing, Barnwell is not an operational facility, and much of their work will have to be demonstrated and evaluated in a working environment.

Direct support for international safeguards is likewise limited by the lack of operating and accessible facilities within the United States. The United States sponsors a Program of Technical Assistance to IAEA Safeguards to ensure that IAEA does not lack technical assistance which the United States could supply. In 1977 IAEA requested the United States to do four tasks to improve material control and accountability and containment and surveillance safeguards for reprocessing plants. These tasks were deleted from the U.S. program because an operating facility was not available to test the instruments.

Since then, some of these tasks have been incorporated in the Tokai Advanced Safeguards Technology Exercise. This is a research and development effort jointly sponsored by the United States, Japan, France, and IAEA at the Tokai

reprocessing facility in Japan. While this cooperative exercise will test some advanced safeguards instrumentation and should provide some useful results, it is not considered an operational evaluation for integrated safeguards. Only individual pieces of equipment, rather than integrated systems, are being tested. In addition, a researcher at one DOE laboratory said he has been denied access to parts of the plant as well as necessary charts of the material flow system because of commercial sensitivity. He did not believe the Tokai exercise would lead to the development of an integrated safeguards system because many of the activities are merely paper studies, and only four safeguards instruments will actually be tested in the plant.

CURRENT REPROCESSING SAFEGUARDS RESEARCH AND DEVELOPMENT EFFORTS LACK DIRECTION AND CONTROL

In spite of the limited funding for reprocessing safeguards research and development work, DOE could do a better job of managing what work it is conducting. The current program lacks management support, direction, and control for assessing safeguards needs and priorities. DOE has not formulated a comprehensive approach for solving safeguards problems in operating Federal facilities, or in commercial facilities subject to international safeguards.

DOE sponsors research and development for improved safeguards at 12 national laboratories. Each year DOE requests them to submit proposals for safeguards projects which DOE/OSS reviews for funding. The manner in which funding decisions are made is reactionary. OSS has not formulated a plan to conduct safeguards research and development work. As a result, the approach being pursued is fragmented, piecemeal, dependent on various researchers' priorities, and hence does not represent an integrated safeguards plan. An official from the Safeguards Development Office at the Idaho Chemical Processing Plant says this lack of a comprehensive program has adversely affected the safeguards program at Idaho and at other laboratories. According to this official, DOE is not approaching safeguards research and development in a coordinated sense. DOE headquarters is not providing sufficient direction to the laboratories and therefore, the laboratories seem to be dictating projects to DOE.

A May 1979 report sponsored by DOE and performed by the Pacific Sierra Research Corporation, a consulting organization, pointed out additional weaknesses in DOE's safeguards program. The study identified the most crucial

problems of safeguarding DOE facilities that handle significant quantities of weapons-usable material. Concerning DOE's safeguards research and development program, the study concluded that funding priorities do not realistically address research and development needs. The problem stems, essentially, from the lack of a framework or methodology for assessing safeguards needs, consensus on overall safeguards priorities, and centralized requirements for implementing safeguards in facilities.

Until a comprehensive safeguards research and development program is developed which identifies program needs and assesses priorities, DOE will not be able to direct its laboratories to conduct the research needed to solve the major safeguards problems in its own facilities and for international reprocessing safeguards activities. OSS officials agree with the need for such a plan and say they are currently preparing one to formulate such a comprehensive approach. This plan, however, is directed toward safeguards for "fuel cycle facilities" and will not represent a comprehensive domestic and international safeguards approach for reprocessing.

In commenting on this report, DOE said that its safeguards research and development program is budgeted to give priority to more sensitive and immediate problems with somewhat less priority given to baseline technology development. In an era of extreme budget consciousness, DOE must provide its highest priorities toward meeting statutory and executive order requirements to provide adequate protection to DOE facilities and operations.

CONCLUSION

The large amounts of weapons-usable material that are and will be produced by reprocessing facilities and the limitations of conventional safeguards technology reinforces the U.S. concern about weapons proliferation. In order to counter this threat, effective domestic and international safeguards systems need to be in place before commercial-size reprocessing facilities begin operation. No such safeguards currently exist.

If commercial reprocessing is to be a safe, proliferation-resistant industry, and if the United States is to be in a position to influence and promote its nonproliferation objectives, it must develop effective domestic and international safeguards concepts and technologies. While the United States has always maintained a leadership role in the safeguards research and development area, the April 1977 deferral policy has constrained

its program to advance safeguards technology for reprocessing. Until adequate safeguards are developed and appropriate institutional and procedural systems are operating to complement technology, commercial reprocessing will remain a proliferation risk and a threat to world peace and stability.

RECOMMENDATION TO THE SECRETARY OF ENERGY

The Secretary of Energy should direct the Office of Safeguards and Security to develop a comprehensive program which systematically identifies reprocessing safeguards needs, establishes research priorities, and provides for a plan to conduct research to solve these problems and to demonstrate integrated safeguards systems for commercial and international application.

APPENDIX I

THE DEPARTMENT OF ENERGY'S FEBRUARY 8, 1980 COMMENTS ON A DRAFT OF THIS REPORT AND GAO'S EVALUATION OF THE COMMENTS

Mr. J. Dexter Peach
Energy and Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report "Nuclear Fuel Reprocessing and the Risk of Worldwide Nuclear Weapons Proliferation." The Department of Energy (DOE) has strong reservations regarding certain safeguards issues presented in the draft report. Our views with respect to these reported questionable issues follow:

Differences between domestic and international safeguards

The draft report misleads the reader by linking inventory differences at Federal reprocessing facilities against the threat of national proliferation through diversion. The resulting conclusion may reflect a misunderstanding of the differences between domestic and international safeguards and the distinct resources available to each system to counter their respective threats.

Domestic safeguards are developed and put in place to counter in real-time a postulated subnational threat to divert or steal special nuclear material (SNM) or commit acts of sabotage. The central mission of domestic safeguards is to prevent such acts. To accomplish this, domestic safeguards' first lines of defense are physical security and material control. These measures are complemented by materials accountability systems employed to detect and deter attempted diversion and to provide independent, after the fact, checks on the effectiveness of the physical protection and material control systems.

International safeguards are put into place to counter the threat of national diversion from peaceful

nuclear programs to nuclear weapons. Because physical security is properly the preserve of the sovereign states, international safeguards are comprised of materials accountability measures complemented by certain material control measures whose sole mission is to detect national diversion of significant amounts of material.

While the draft report has properly noted that international safeguards share some basic elements with domestic safeguards, i.e., material control and materials accountability, the application of these technologies is inherently different in the two systems. Because international safeguards must detect national diversion, its time frame for an effective alarm can be the 1 to 3 weeks cited in the draft report as a goal. Since domestic safeguards operate principally before-the-fact in their physical security-prevention mode, the application of the international detection goal is not appropriate.

GAO EVALUATION

As stated on page 8 of the report, the purpose of the review was to determine the relationship between commercial spent fuel reprocessing and worldwide weapons proliferation and the adequacy of safeguards technology to detect diversions of weapons-usable material and subsequently reduce the proliferation risks of reprocessing. Since the two DOE facilities were the only reprocessing facilities operating in the United States, we assessed the effectiveness of the safeguards technology being used at them, placing particular emphasis on material control and accountability which would have applicability to a commercial facility subject to international safeguards. To verify that the problems identified within DOE's facilities are problems on an international level, we visited the Tokai Mura plant in Japan, which is currently being used as a test site for international safeguards instrumentation.

GAO recognizes and points out in the report the differences between domestic and international safeguards. The perceived threat and primary modes of defense are different. As a result, we concentrated our review on the technology used in material control and accountability over weapons-usable material present in a reprocessing plant. This technology is the same for DOE facilities and commercial facilities subject to international safeguards. Our review found that technology is not available to control and account for all weapons-usable material within reprocessing facilities in a timely manner.

DOE COMMENT

Effectiveness of DOE safeguards

It is misleading to discuss the effectiveness of U.S. domestic safeguards at Federal reprocessing facilities in terms which are inappropriate to the subnational threat. Whereas it may be true that the accountability measures at Idaho Chemical Processing Plant and at Savannah River cannot assure detection of diversion in a 1 to 3 week time frame, that fact has limited bearing on the overall effectiveness at those installations in view of the primary roles of physical protection and material control.

Effectiveness for domestic safeguards applications is not strictly quantifiable. It is an overall judgment based in part upon quantifiable elements (such as inventory difference) and on the current picture of the subnational threat, the extent of attempts on the system, and the other measures in place.

Irrespective of the degree of quantification of effectiveness, there will always be some residual risk that the system can be defeated. DOE's approach is to reduce these risks to acceptable levels in terms of national security and public health and safety.

GAO EVALUATION

Whereas GAO agrees that effectiveness is not strictly quantifiable, we do not believe it should be an entirely subjective determination. DOE has not established any timeliness criteria that can be applied to its safeguards systems. In commenting on our draft DOE said its material accountability systems are employed to prevent and detect attempted diversions and provide independent, after the fact, checks on the effectiveness of the physical protection and material control systems. Since we had no time criteria against which to assess the effectiveness of DOE's material control and accountability systems, we used the criteria of 1 to 3 weeks which IAEA's SAGSI considers the time required to convert nuclear material into an explosive device. Although DOE officials do not believe this time frame is appropriate for domestic safeguards, we used it because DOE could not provide us an applicable time frame. It should be noted, however, that if DOE were given an

infinite amount of time, it would not be able to account for all weapons-usable material processed by its facilities.

In light of the fact that DOE admits there will always be some residual risk that its physical security system can be defeated and because of the problems we noted in the physical security systems at the two DOE facilities, we believe that material accountability plays an important role in effective safeguards, both on a domestic and international level. Until DOE can account for weapons-usable material in its facilities in a timely manner, it will continue to be unable to assure the public that its physical security system has not been breached.

DOE COMMENT

Inventory differences: their safeguards role

In regard to inventory differences, the draft report states that "material control and accountability systems are unable to account for weapons-grade material in a timely manner." This statement is placed in the context of the historical inventory differences observed at the Savannah River reprocessing plant.

The draft report has approached these inventory differences from the perspective that they demonstrate inadequate safeguards. By making this observation, an incorrect safeguards role is assigned to numbers which ignores the complementary nature of materials accountability. Inventory differences are the arithmetic difference between the amount of material shown in the accounting records and the amount that a physical inventory shows to be actually present. These numbers are the net result for the nuclear materials accountability systems. Inventory differences have a limited role in determining whether a diversion has occurred. In particular, as DOE's predecessor, the Energy Research and Development Administration (ERDA) noted in its first reporting of historical inventory differences in August of 1977 ("Report on Strategic Special Nuclear Material Inventory Difference," ERDA 77-68, August, 1977), "Inventory differences are expected in nuclear material processing and are not, in and of themselves, evidence of lost or

stolen material. On the other hand, inventory difference analysis provides valuable information on the effectiveness of the safeguards system's physical protection and material control measures as well as a check on the process controls and material management procedures."

GAO EVALUATION

We believe the inventory differences at the Federal facilities are significant because they reflect the technological limitations of conventional material control and accountability systems being used in operating military and/or commercial reprocessing facilities, both within the United States and abroad. Although improvements in material accountability technology are predicted in future facilities, many of the problems noted in our report will still exist. These limitations will adversely impact the ability of domestic and international safeguards to detect diversions of weapons-usable material from peacefully-dedicated facilities. These same technological limitations also preclude DOE from assuring that its physical security and material control systems are effective at preventing diversions of weapons-usable material from its facilities.

DOE COMMENT

Safeguards research and development: controls and priorities

On the basis of the perceived inadequacies at U.S. reprocessing facilities, the draft report cites that the "current safeguards research and development effort lacks direction and control." Included in this perception was the contention that DOE did not have a systematic way for establishing safeguards research and development priorities.

It is not true that DOE's safeguards R&D lacks direction and control. Management control is exercised through a variety of formal internal and external mechanisms. These include annual program plans, development of multi-year (five years) internal budget reviews, annual formal direction to the field through program direction letters, and external budget and program review by OMB.

As to priorities, DOE's safeguards R&D is budgeted to give priority to the more sensitive and immediate problems with somewhat less priority given to baseline technology

development. In an era of extreme budget consciousness, DOE has assigned highest priority to statutory and executive order requirements to provide adequate protection to the DOE's facilities and operations. Unfortunately, programs in safeguards R&D that are focused on longer-term problems, including international safeguards for commercial reprocessing, must be assigned a lesser priority. DOE has not deemphasized safeguards development for the Federal reprocessing facilities.

GAO EVALUATION

We based our conclusion that DOE's safeguards research and development effort lacks direction and control on extensive audit work at six DOE laboratories currently doing its research work and after thorough discussions with numerous OSS officials responsible for DOE's safeguards research and development effort. In addition, as pointed out on page 51 of our report, the Pacific Sierra Research Corporation independently reached the same conclusion in a study that was sponsored by DOE.

We sympathize with the budget constraints that DOE is currently experiencing. These constraints, however, reinforce the need to systematically identify the problems that its safeguards research program could be addressing and to prioritize the work that should be done so that the limited funds can be used to solve the most significant problems. Since the President believed commercial reprocessing posed such a risk to the further spread of nuclear weapons that he indefinitely deferred its commercialization within the United States, we believe that DOE should emphasize research that could reduce its proliferation risk by developing more effective domestic and international safeguards technologies.

DOE COMMENT

Reprocessing safeguards research and development

DOE continues to fund a broad variety of safeguards systems and component development for application to the Federal reprocessing complex. Some of these efforts have direct applicability to commercial installations. Included in these efforts are:

--Closed loop control systems

--Instruments to measure the plutonium content of spent fuel

--Improved accuracy of input and product measurements

--System improvements to effect more timely closing of material balances

--Instruments to measure SNM content of waste streams

--Automated reprocessing plant monitoring system.

GAO EVALUATION

DOE has deemphasized safeguards research for reprocessing plants and is funding safeguards research at a minimal level. GAO attempted to determine the specific impact the deferral policy had on DOE's reprocessing safeguards research, but was unable to do so. DOE could not provide funding information for fiscal years 1976-78. Our statement that the policy redirected efforts away from reprocessing facilities is based on numerous statements made by researchers at DOE laboratories, and by DOE/OSS officials. DOE/OSS officials commented that it would be difficult to perform the necessary research under the current administration policy, as funding would most likely be denied for such work. That research and development funding information DOE could provide supports our conclusion. As can be seen by the information presented on page 47, DOE is not planning to fund any projects from fiscal years 1979 through 1981 for material control and accountability instruments to improve the accuracy of input and product measurements, is spending only $70,000 to determine the plutonium content of spent fuel, and only $400,000 to measure the plutonium content of waste streams. We believe these research areas are in need of attention and that improvements in these and other areas would benefit safeguards not only for DOE facilities but also for facilities located outside of the United States which are, or will be, subject to international safeguards.

DOE COMMENT

Application of near-real-time accountability system to reprocessing facilities

The draft report notes that the DYMAC process now operational on a batch-scale process line at Los Alamos could be effectively applied to internationally-safeguarded reprocessing plants. While certain aspects of the near-real-time system concept can and will be developed for application at purex-based reprocessing facilities, DYMAC is designed around a batch rather than continuous flow process and would not be directly applicable. Other reasons for proceeding cautiously with the application of near-real-time systems for foreign facilities include their high cost, relative to more conventional safeguards measures, and the resistance on the part of the foreign facility operators to what they would view as excessive "intrusiveness" by the International Atomic Energy Agency (IAEA). That degree of access is reflected in the need of the IAEA as the safeguards authority to have data from all key measurement points within the reprocessing plant. These data are usually considered to be commercially sensitive, and this degree of access by IAEA (both technology and inspectors) may be politically sensitive as well. The denial of access to a Los Alamos Scientific Laboratory (LASL) staff member at Tokai Mura cited by the GAO is evidence of this.

GAO EVALUATION

Neither the draft nor the final report note that the DYMAC process used at Los Alamos could effectively be applied to internationally-safeguarded reprocessing plants. We state "* * * the two Federal reprocessing facilities could be used to demonstrate, in part, the feasibility of the Los Alamos [DYMAC] near-real-time accountability concept." (See p. 49.)

Although the DYMAC system is based on a batch process, Los Alamos researchers are confident it could successfully be applied to certain parts of the DOE reprocessing plants, particularly in the plutonium purification process area. We realize that as with most concepts, DYMAC per se cannot merely be transferred to another facility but must be tailor-fit to specific facilities and evaluated in them. The near-real-time accountability concept has merit, however, and

should be thoroughly evaluated to select cost-effective system components and to assess the degree to which it could provide useful information in a continuous, rather than batch flow, facility. Currently, the concept is being applied only in a portion of a plutonium fabrication facility. IAEA believes, and has stated, that development and demonstration of this concept is needed and that it could result in improved diversion sensitivity time for international safeguards' purposes.

DOE's comment regarding access to Tokai Mura reinforces the fact that IAEA will have difficulty safeguarding facilities because of the limited information it is allowed to collect. As larger facilities start operations, some type of international consensus must be reached on the degree to which IAEA will be allowed facility access, and the type of information it will require from all reprocessing nations.

DOE COMMENT

International reprocessing:
U.S. policy implications

The report states: "The administration's policy of indefinitely deferring commercial reprocessing of nuclear fuel had little or no impact on the reprocessing programs and plans of other nations." This statement is misleading. The deferral decision was only one component of a broader policy intended to discourage premature reprocessing and widespread use of plutonium.

This policy was begun under President Ford and confirmed and strengthened by President Carter. In addition to the deferral of U.S. reprocessing, this policy consisted of encouraging other countries to use caution in moving toward a plutonium economy; urging others to exercise restraint in the export of reprocessing technology; exercising U.S. bilateral rights over U.S. origin fuel to allow reprocessing only when needed; and initiating a major international evaluation (INFCE) to examine technical and institutional measures to reduce the risks of proliferation associated with reprocessing.

As a result of all of these efforts, there has been a growing awareness of the dangers of reprocessing as well as a recognition of the importance of reducing those dangers

to an acceptable level. Some countries have deferred or abandoned their reprocessing plans over the last several years. In addition, two of the large nuclear states, the United Kingdom and West Germany, have experienced major domestic debates on the importance, timing and risks of reprocessing. West Germany plans to construct an integrated reprocessing center at Gorleben have been deferred, and a decision on reprocessing will not be made until 1985.

The reference to the fact that many countries are reprocessing or planning to reprocess "indicate that the commercial reprocessing industry is continuing to grow" is misleading. It does not take into account the fact that the reprocessing of commercial quantities of high burn-up light water reactor fuel has yet to be fully demonstrated. Given the uncertainties surrounding reprocessing (environmental opposition, public acceptance, economics, proliferation risks), it is premature to assert that commercial reprocessing will continue to grow.

The draft report section entitled "International Control Over Separated Plutonium Is Lacking" contains a seriously distorted picture of the U.S. position toward the IAEA-sponsored study in international plutonium storage. This section contains little if any analysis of the need for, timing or shape of an international plutonium storage system.

GAO EVALUATION

On page 30, we have included a statement that the administration's policy and the INFCE program have made other nations more aware of the proliferation risks of reprocessing. However, our basic point remains true--that in spite of the U.S. policy, the worldwide nuclear fuel reprocessing industry continues to grow. This conclusion is based on discussions with foreign government and utility and/or U.S. embassy officials from 9 nuclear energy producing countries. We also carefully analyzed the reprocessing plans of those countries participating in the INFCE program. Based on these discussions and analyses, we found that many countries are operating or planning to operate reprocessing facilities. In reference to the United Kingdom and West Germany domestic debates, the United Kingdom's Windscale Inquiry determined that reprocessing was a necessary part of that nation's nuclear

energy program, and that its decision had little to do with U.S. nonproliferation policy. In West Germany, the large Gorleben project has become a political, anti-nuclear issue within Gorleben's province, and is being delayed. In commenting on our draft report, DOE officials said they believe considerable uncertainties exist about the future of commercial reprocessing. We incorporated this comment on page 31 of the report.

GAO's treatment of the international plutonium storage regime was also reviewed by responsible officials from the Department of State and the Arms Control and Disarmament Agency who generally agreed that the information presented is factually correct. DOE complains that the report gives them little guidance as to the need for, timing or shape of an international plutonium storage system. Our belief that the United States needs to become involved in establishing such a system is based on the fact that:

--25 tonnes of separated plutonium currently exist, and future stockpiles are expected to reach 885 tonnes by the year 2000;

--the United States has limited or no influence over these stockpiles;

--other nations are moving forward with the international plutonium storage concept;

--the United States currently has limited control over the reprocessing of fuel it has supplied to nations; and

--the present time appears to be the most advantageous time for the United States to exert its influence.

In reference to the timing and shape of an international plutonium storage system, we believe these are exactly the types of issues DOE and the administration should be addressing in formulating a system that would satisfy both U.S. non-proliferation objectives and the needs of the international community.

DOE COMMENT

Supplemental comments on each chapter are being provided to members of your staff by DOE's Office of

APPENDIX I

Safeguards and Security. We will be pleased to provide any additional information that is necessary in this matter.

Sincerely,

Jack E. Hobbs
Controller,
Department of Energy

GAO NOTE: Supplemental comments provided by DOE's Office of Safeguards and Security were incorporated in the report where appropriate.

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