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There has been much concern that nations with commercial nuclear powerplants but not possessing nuclear weapons might attempt to divert the plutonium contained in the spent fuel discharged from their powerplants to make nuclear weapons. Concerns were increased by an Oak Ridge National Laboratory memorandum dated August 30, 1977, which provided a conceptual design for a simple and quick plant for reprocessing spent nuclear fuel. Findings/Conclusions: The major issue raised by the memorandum was whether the reprocessing plant could be built and operated by nonnuclear-weapons nations without time constraints, quickly, and secretly. Without time constraints, many of these nations have, or could acquire, the technical capability to build and operate such plants. There was a wide divergence of opinion on how quickly such a plant could be built and placed into operation. The memorandum's estimate of 4 to 6 months, although not highly probable, is credible under some circumstances. GAO had limited access to information relating to the secrecy issue. Agencies involved believed that development and operation of a reprocessing plant would involve a substantial risk of detection. GAO noted, however, that there are limitations in the scope and applicability of detection activities. The possibility of quick construction of secret reprocessing plants is not a significant factor in deciding whether to allow reprocessing of spent fuel; the primary focus of U.S. policy is on the spread of legitimate reprocessing plants. However, the memorandum reemphasized the importance of deterring nonnuclear-weapons nations from diverting spent fuel. (HTW)

REPORT BY THE

Comptroller General

OF THE UNITED STATES

Quick And Secret Construction Of Plutonium Reprocessing Plants: A Way To Nuclear Weapons Proliferation?

An August 30, 1977, Oak Ridge National Laboratory memorandum provides a conceptual design for a "simple and quick" plant for reprocessing spent nuclear fuel. Because it has raised the issue of quick construction of secret reprocessing plants in countries which do not now have nuclear weapons, the Chairman, Subcommittee on Energy, Nuclear Proliferation and Federal Services, Senate Committee on Governmental Affairs, asked GAO to examine the concept's credibility and policy implications.

GAO concludes that (1) the Oak Ridge estimate of 4 to 6 months for constructing a small reprocessing facility, although not highly probable, should be considered credible in some circumstances, (2) the possibility of quick construction of secret reprocessing plants is not a significant factor in deciding whether to allow reprocessing of spent fuel, and (3) the memorandum serves to reemphasize the importance of U.S. initiatives to improve controls on spent nuclear fuel.





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

B-151475

The Honorable John Glenn
Chairman, Subcommittee on Energy,
Nuclear Proliferation and
Federal Services
Committee on Governmental Affairs
United States Senate

Dear Mr. Chairman:

In response to your request of November 15, 1977, here are the results of our evaluation of the major issues raised by an Oak Ridge memorandum dated August 30, 1977. As you know, the Oak Ridge memorandum provided a conceptual design for the construction of a "simple and quick" reprocessing plant. This report, as we agreed with your office, will be available for unrestricted distribution.

We provided the Arms Control and Disarmament Agency, the Central Intelligence Agency, the Department of Energy, the Department of State, and the Nuclear Regulatory Commission an opportunity to review a draft of this report. Their comments have been incorporated in the report as we believed appropriate.

Although the Central Intelligence Agency commented on our draft report, officials of the Agency declined to meet with us during our review. We were informed that such a meeting would not be appropriate because discussion of the issues might reveal the Agency's sources, methods, and capabilities. Lack of access to intelligence information from the Agency limited the scope of our review to information from other Federal agencies and sources as described in the report.

Sincerely yours,

A handwritten signature in black ink, appearing to read "James B. Atchafalua".

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT
TO THE SUBCOMMITTEE ON ENERGY,
NUCLEAR PROLIFERATION AND
FEDERAL SERVICES
COMMITTEE ON GOVERNMENTAL
AFFAIRS
UNITED STATES SENATE

QUICK AND SECRET CONSTRUCTION
OF PLUTONIUM REPROCESSING
PLANTS: A WAY TO NUCLEAR
WEAPONS PROLIFERATION?

D I G E S T

There is considerable concern that nations with commercial nuclear powerplants but not possessing nuclear weapons might attempt to divert the plutonium contained in the spent fuel discharged from their powerplants to make nuclear weapons. This concern was heightened with the wide distribution of an Oak Ridge National Laboratory memorandum dated August 30, 1977, which provides a conceptual design for a simple and quick plant for reprocessing spent nuclear fuel.

GAO examined reviews of the Oak Ridge memorandum by five Federal agencies and by 11 individuals and organizations with diverse backgrounds in nuclear energy and nonproliferation matters. (See pp. 2 to 4.) The examination primarily focused on:

- How credible are quick and secret reprocessing plants?
- What are the policy implications?

HOW CREDIBLE ARE QUICK AND
SECRET REPROCESSING PLANTS?

The major issue raised by the Oak Ridge memorandum consists of whether the reprocessing plant could be built and operated by nonnuclear-weapons nations

- without time constraints,
- quickly, and
- secretly.

The technical capability issue

GAO concluded that without time constraints many nonnuclear-weapons nations have, or could acquire, the technical capability to build and operate reprocessing plants as envisioned in the Oak Ridge memorandum, and such nations could recover weapons-usable plutonium from spent nuclear fuel. GAO based this conclusion on the following factors:

- There is considerable worldwide experience in building and operating reprocessing plants of various sizes, some of which are located in nonnuclear-weapons nations.
- Even before the Oak Ridge memorandum, several experts had found that small reprocessing plants described in unclassified information that is widely published could be built by several nations by using materials and equipment that are commercially available.
- No review of the Oak Ridge memorandum that GAO examined said the construction and operation of a small reprocessing plant by nonnuclear-weapons nations was not technically feasible; also, no review said that weapons-usable plutonium could not be recovered from from such a plant. (See pp. 5 to 7.)

The quickness issue

There was a wide divergence of opinion among the reviewers of the Oak Ridge memorandum on how quickly a small reprocessing plant could be built and placed into operation by nonnuclear-weapons nations. With little attention to the problems of safely handling radioactive materials, the Oak Ridge memorandum estimates that a small reprocessing facility could be built in only 4 to 6 months after breaking ground. The first 10 kilograms of plutonium could be recovered about a week after initial operation, and about 5 kilograms of plutonium per day thereafter. This would be enough plutonium for more than one nuclear weapon a week.

The Oak Ridge memorandum did not address all the time requirements which some Federal agencies considered important. It did not consider steps before construction started, such as the time to design the plant, recruit and train designers and operators, find a suitable site, or stockpile critical equipment.

The estimate also did not include steps after construction was completed, such as time to test the plant or to divert and transport spent fuel to the plant. When these types of requirements are considered, the estimate increases to about 19 months according to the Department of Energy, 24 months or more according to the Arms Control and Disarmament Agency, and 24 to 30 months according to the Congressional Research Service.

Because of differences in expert opinions on the need to consider certain steps before and after construction of the plant and because of the wide diversity of the technical capabilities of nonnuclear-weapons nations, particularly the availability of qualified technicians, GAO could not reduce the general uncertainty in the time range of the various estimates. Of course, building a plant quickly rather than building it more carefully and testing it before use would have a lower probability of operating successfully. Nevertheless, GAO believes the Oak Ridge memorandum's estimate of 4 to 6 months, although not highly probable, should be considered credible in some circumstances. (See pp. 7 to 9.)

The secrecy issue

If secrecy can be maintained, the question of how quickly a nonnuclear-weapons nation could build and operate a secret reprocessing plant is relatively unimportant. GAO was limited in its efforts to determine whether a small reprocessing facility could be built secretly because the Central Intelligence Agency denied it access to information.

According to the Department of Energy, however, the risk of detection would begin at the time of a national decision to construct a secret plant and would involve many steps before the plutonium could be used for a nuclear explosive device. Each new step could involve more people who know of the plan and hence could increase detection. In addition, each new operation involves the potential for unforeseen incidents which may cause disclosure.

The Arms Control and Disarmament Agency and the Department of State believe that undetected operation of a secret reprocessing plant is unlikely. GAO noted, however, that although a substantial risk of detection may exist there are limitations in the scope and applicability of some detection activities. The deterrent value of these activities is not clear. (See pp. 9 to 12.)

WHAT ARE THE POLICY IMPLICATIONS?

The U.S. policy on nuclear proliferation is intended to limit the number of nations with nuclear explosive capabilities. While there are several ways a nation could obtain the essential nuclear materials needed for nuclear explosive devices, current U.S. policy focuses heavily on discouraging the worldwide spread of reprocessing facilities, which would provide direct access to plutonium. This access, or even the capability of recovering plutonium from the spent fuel of nuclear powerplants, can lead to the risk that it would be used for nuclear explosive devices. (See p. 14 and app. I.)

The Oak Ridge memorandum has been used to question U.S. policy toward reprocessing. (See p. 15.)

The Arms Control and Disarmament Agency, the Department of Energy, and the Department of State believe the possibility of quick construction of secret reprocessing facilities does not support the need for any basic changes in U.S. policy toward reprocessing. (See p. 16.)

GAO believes the possibility of quick construction of secret reprocessing plants is not a significant factor in deciding whether to allow reprocessing of spent fuel. Secret plants do not have a direct relationship to the spread of legitimate reprocessing plants which are the primary focus of U.S. policy. The further spread of these plants without assurances they would be adequately safeguarded clearly presents greater proliferation risks than, and is a separate issue from, the possibility of secret reprocessing plants. (See pp. 16 and 17.)

Because many nonnuclear-weapons nations have, or could acquire, the technical capability to build and operate small reprocessing plants, the Oak Ridge memorandum serves to reemphasize the importance of deterring nonnuclear-weapons nations from diverting spent fuel to such plants. The United States, however, recognizes the importance of this concern and has recently taken action addressing it.

Although it is too early to say how successful these actions will be, GAO will be evaluating the implementation and impact of these actions on U.S. nonproliferation policy in response to a mandate of the Nuclear Non-Proliferation Act of 1978. (See pp. 17 to 19.)

AGENCY COMMENTS

GAO received comments on a draft of this report from the Arms Control and Disarmament Agency, the Central Intelligence Agency, the Department of Energy, the Department of State, and the Nuclear Regulatory Commission. Their comments have been incorporated throughout the report as GAO believed appropriate.

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ABBREVIATIONS

CIA	Central Intelligence Agency
DOE	Department of Energy
GAO	General Accounting Office
IAEA	International Atomic Energy Agency
ORNL	Oak Ridge National Laboratory
OTA	Office of Technology Assessment

CHAPTER 1

INTRODUCTION

Nuclear powerplants in use throughout the world today create plutonium--a material that can be recycled and used again as nuclear fuel or to make nuclear weapons. However, before the plutonium can be used the spent fuel must be reprocessed to separate the plutonium from other radioactive byproducts created during the powerplant's operation.

For many years there has been concern that nations with commercial nuclear powerplants but not possessing nuclear weapons (hereafter referred to as nonnuclear-weapons nations) might attempt to reprocess the plutonium in spent nuclear fuel to make nuclear weapons. This concern was heightened with the distribution of an August 30, 1977, Oak Ridge National Laboratory (ORNL) memorandum providing a conceptual design for a "simple and quick" reprocessing plant. Consequently, on November 15, 1977, the Chairman, Subcommittee on Energy, Nuclear Proliferation and Federal Services, Senate Committee on Governmental Affairs, asked that we examine the design's credibility and its implications for U.S. policy. This report is in response to the Chairman's request and subsequent agreements with his office.

THE OAK RIDGE MEMORANDUM

On August 30, 1977, the Division Director of the Chemical Technology Division, ORNL, sent an informal 23-page memorandum to the then-Deputy Director, ORNL, on the problems of constructing a "simple and quick" reprocessing facility for the recovery of plutonium from spent fuel. In some manner the memorandum has since received wide unauthorized distribution.

ORNL is a Government-owned, contractor-operated laboratory involved in energy technology research, development, and demonstration primarily for the Department of Energy (DOE). DOE officials stated that the Oak Ridge memorandum was not approved by DOE, nor was it reviewed by DOE representatives before distribution. Therefore, the views expressed in the Oak Ridge memorandum are those of the ORNL staff who prepared it and not DOE or other Federal agencies.

The Oak Ridge memorandum lists the major equipment and primary processes required to construct a small reprocessing facility to recover plutonium from spent fuel only 4 to 6 months after breaking ground. The first 10 kilograms of plutonium could be recovered about a week after initial operation

and about 5 kilograms of plutonium per day thereafter. This would be enough plutonium for more than one nuclear weapon a week.

The Oak Ridge memorandum assumes the availability of materials and equipment, adequate and ready funds, and a supportive populace. In addition, the memorandum noted that some materials could be acquired from a small industry such as a winery, dairy, or oil refinery.

It is important to recognize at the outset of this report that the Oak Ridge memorandum deals primarily with a design concept. A nonnuclear-weapons nation could not successfully construct a reprocessing plant solely on the basis of the unclassified information contained in the memorandum. According to DOE there is insufficient detail to enable construction of a plant without further design effort. Further, the Oak Ridge memorandum gives little attention to problems of safely handling radioactive materials.

SCOPE OF REVIEW

We examined a number of reviews of the Oak Ridge memorandum in analyzing the credibility and policy implications. These reviews represented a wide spectrum of expert opinion on the issues from individuals and organizations with diverse backgrounds in nuclear energy and nonproliferation matters.

Specifically, we examined reviews by the following Federal agencies:

- The Arms Control and Disarmament Agency.
- The Department of Energy.
- The Department of State.
- The Nuclear Regulatory Commission.

We also examined a preliminary analysis of the Oak Ridge memorandum conducted by the Congressional Research Service. We also contacted the Central Intelligence Agency (CIA) for their views. CIA officials, however, declined to meet with us.

Further, we examined the reviews of the following individuals and organizations:

- Dr. Manson Benedict, Institute Professor Emeritus, Massachusetts Institute of Technology.
- Dr. Thomas B. Cochran, Senior Staff Scientist, Natural Resources Defense Council, Incorporated.
- Mr. Louis M. Favret, Vice President, Nuclear Divisions, Babcock and Wilcox.
- Mr. Victor Gilinsky, Commissioner, Nuclear Regulatory Commission.
- Dr. Robert V. Laney, Deputy Director of Operations, Argonne National Laboratory.
- Mr. Wesley H. Lewis, Vice President, Nuclear Fuel Services, Incorporated.
- Mr. Charles F. Luce, Chairman of the Board, Consolidated Edison Company of New York, Incorporated.
- Mr. W. J. Maraman, University of California, Los Alamos Scientific Laboratory.
- Mr. Milton Shaw, private consultant; former Director of the Atomic Energy Commission's Reactor Development and Technology program.
- Mr. John Taylor, Vice President and General Manager, Water Reactor Divisions, Westinghouse Electric Corporation.
- Dr. Albert Wohlstetter, University Professor, University of Chicago.

Our report is based on our examination of the above reviews, plus our previous involvement in evaluating nuclear fuel reprocessing and nonproliferation issues which provided a basis for the following GAO reports:

- "An Evaluation of Federal Support of the Barnwell Reprocessing Plant and the Department of Energy's Spent Fuel Storage Policy" (EMD-78-97, July 20, 1978).
- "An Evaluation of the Administration's Proposed Nuclear Nonproliferation Strategy" (ID-77-53, October 4, 1977).

- "Nuclear Energy's Dilemma: Disposing of Hazardous Radioactive Waste Safely" (EMD-77-41, September 9, 1977).
- "An Evaluation of the National Energy Plan" (EMD-77-48, July 25, 1977).
- "Issues Related to the Closing of the Nuclear Fuel Services, Incorporated, Reprocessing Plant at West Valley, New York" (EMD-77-27, March 8, 1977).
- "Role of the International Atomic Energy Agency in Safeguarding Nuclear Material" (ID-75-65, July 3, 1975).

CHAPTER 2

HOW CREDIBLE ARE QUICK AND SECRET

REPROCESSING PLANTS?

The major issue raised by the Oak Ridge memorandum is whether nonnuclear-weapons nations could quickly and secretly build and operate a small reprocessing plant to recover weapons-usable plutonium from spent nuclear fuel. This issue has three parts: (1) could the plant be built and operated by nonnuclear-weapons nations without time constraints, (2) could it be built and operated quickly, and (3) could it be built and operated secretly.

THE TECHNICAL CAPABILITY ISSUE

No reviewer of the Oak Ridge memorandum said that the construction and operation of a small reprocessing plant by nonnuclear-weapons nations was not technically feasible. However, several reviewers did believe that the plant described in the Oak Ridge memorandum had a low probability of operating successfully, particularly if the nation attempting it did not have the technical experience of the ORNL staff.

DOE's review noted that a small, crude plant could be built without difficulty, but experienced personnel would be required to operate it. The materials necessary for constructing the plant would be available or could be manufactured or imported by a nation having industries such as wineries, dairies, and petroleum refineries, according to DOE. In addition, DOE said those nations with nuclear powerplants would have experienced personnel and possibly equipment for transporting spent fuel.

There is considerable worldwide experience in building and operating reprocessing plants of various sizes, some of which are located in nonnuclear-weapons nations. All nuclear-weapons nations (France, the Soviet Union, the People's Republic of China, the United Kingdom, and the United States) ^{1/} have plutonium reprocessing plants dedicated to military purposes. Today, the only operating commercial reprocessing plant is in France. The United Kingdom has temporarily closed down a large commercial plant for upgrading. The United States does not have an operating commercial reprocessing plant, although one operated from 1966

^{1/}Although India has detonated one nuclear device asserted to be for "peaceful" purposes, India is not known to possess actual nuclear weapons.

to 1972. At least four nonnuclear-weapons nations already have laboratory, pilot, or near-commercial reprocessing facilities (Federal Republic of Germany, Italy, India, and Japan). Another five have plans and programs underway for similar facilities (Argentina, Spain, Pakistan, Taiwan, and Yugoslavia). In addition, major commercial reprocessing ventures are in advanced stages of planning and implementation in at least three nonnuclear-weapons nations (Federal Republic of Germany, France, and United Kingdom) and a fourth country (Japan) has similar programs under serious consideration. Further, many nonnuclear-weapons nations participated in the European Nuclear Energy Agency's developmental reprocessing plant in Belgium, which operated from 1966 to 1974.

Building a large commercial size plant would cost hundreds of millions of dollars and many technical problems would have to be solved. However, even before the Oak Ridge memorandum some experts had found that smaller, simpler, and less expensive reprocessing plants could be built by several nations. For example, one expert 1/, in testimony to the Congress in October 1975, stated:

"Contrary to rather widespread belief, separation of plutonium from irradiated nuclear fuel--that is, fuel that has been taken out of nuclear powerplants--and its subsequent incorporation into nuclear weapons suitable for military purposes, is not potentially beyond the capability of most countries. A commercially competitive nuclear fuel reprocessing plant that produces separated plutonium and uranium that meets the stringent quality control specifications required by the nuclear industry, is a highly complex, sophisticated facility, costing at least several hundred million dollars. But a reprocessing facility designed only to extract plutonium for nuclear weapons could be much smaller, simpler, and less expensive.

"One could describe such a facility in a form that would require only a few months for construction and an operating crew of less than a dozen appropriately skilled people, using information that is widely published and materials and equipment that are commercially available worldwide."

1/Dr. Theodore Taylor, Chairman of the Board, International Research and Technology Corporation, testifying before the House Subcommittee on International Security and Scientific Affairs, Committee on International Relations, October 28, 1975.

Further, as noted in the Congressional Research Service review of the Oak Ridge memorandum two analyses 1/ prepared for congressional use reveal that without time constraints there is a strong likelihood of nonnuclear-weapons nations being able to build a small reprocessing plant. These analyses note that all the equipment and supplies required to build and operate a reprocessing plant are generally available on the world market and that all the information required to design the plant is available in unclassified literature.

No reviewer of the Oak Ridge memorandum denied that weapons-usable plutonium could be recovered from the spent fuel of nuclear powerplants in such a facility. In August 1977, the Energy Research and Development Administration announced that a successful nuclear test had been conducted with "reactor grade" plutonium, thus demonstrating that plutonium from spent nuclear fuel is weapons-usable.

THE QUICKNESS ISSUE

There was a wide divergence in opinion among reviewers on how quickly the reprocessing plant envisioned in the Oak Ridge memorandum could be built and operated. For example:

- Mr. Maraman of the Los Alamos Scientific Laboratory noted that there was insufficient information in the Oak Ridge memorandum to estimate construction time.
- Mr. Lewis of Nuclear Fuel Services, Inc., noted that the crude reprocessing scheme outlined in the Oak Ridge memorandum is a sound and technically feasible approach and can be completed well within the time projected.
- Several Federal agencies (Arms Control and Disarmament Agency, Congressional Research Service, DOE, and the Department of State) believe the process has little chance for success in the 4 to 6 months estimated.

1/One was made by Professor John Lamarsh, Head of the Department of Nuclear Engineering, Polytechnic Institute of New York, for the Congressional Research Service; the other was made by the Office of Technology Assessment for the Senate Committee on Government Operations. Although these analyses concern a small reprocessing plant to recover plutonium from a production reactor, according to the Congressional Research Service the situation is not so much more difficult as to make it unlikely that a nation could build a small reprocessing plant to recover plutonium from commercial reactor spent fuel.

The Oak Ridge memorandum did not assess the probability of successful plant construction and operation by nonnuclear-weapons nations within the estimated time frames, nor did it address the availability of qualified technicians with plutonium processing experience. Many reviewers, however, cited the availability of qualified technicians as a major, if not the biggest, factor affecting the probability of successful plant construction and operation within the estimated time frames. For example:

- Dr. Benedict of the Massachusetts Institute of Technology stated that the feasibility of producing 10 kilograms of plutonium within 1 week of starting operations depends in part on whether the designers and operators have prior experience in recovering plutonium from irradiated fuel and converting it to metal and whether the operators are willing to risk radiation exposure.
- Mr. Taylor of Westinghouse Electric Corporation stated that construction and operation of such a crude reprocessing plant would require a highly skilled and experienced group of technologists and engineers since the projected schedule is highly success-oriented.
- The Department of State noted that the project's success or failure is a direct function of the technician's abilities and experience.

The Oak Ridge memorandum also did not address all the time requirements which some Federal agencies considered important in estimating how quickly a nonnuclear-weapons nation could convert spent fuel to weapons-usable plutonium after a national decision to do so. The estimate of 4 to 6 months includes only the time it would take from breaking ground to completing construction of the plutonium recovery plant. It did not consider steps before construction started--such as the time to design the plant, recruit and train designers and operators, find a suitable site, or stockpile critical equipment. The estimate also did not include steps after construction was completed--such as time to test the plant or to divert and transport spent fuel to the plant. When these types of requirements are considered the estimate increases to about 19 months according to DOE, 24 months or more according to the Arms Control and Disarmament Agency, and 24 to 30 months according to the Congressional Research Service.

Opinion among reviewers differed substantially on the need to consider certain steps before and after plant construction.

For example, the Congressional Research Service noted that it seems unlikely that a small reprocessing plant could be started by using irradiated spent fuel without preliminary trials with nonradioactive, fresh fuel. However, the Nuclear Regulatory Commission review noted that the Commission staff believes neither fresh nor spent nuclear fuel is required to test the plant before operation. Further, Mr. Lewis of Nuclear Fuel Services, Inc., noted that while fresh fuel for trial testing could be desirable, it certainly was not a necessity. He noted that the former Nuclear Fuel Services plant at West Valley, New York, was placed into successful operation without the use of fresh fuel for trial testing.

Given these differences in expert opinion and the wide diversity of the technical capabilities of nonnuclear-weapons nations, we cannot reduce the general uncertainty in the time range represented by the Oak Ridge memorandum's 4 to 6 months and the Congressional Research Service's 24 to 30 months. However, building a plant quickly rather than building it more carefully and testing it before use would have a lower probability of operating successfully. How quickly a nonnuclear-weapons nation could build and operate a small reprocessing plant depends on its resources and commitment. With experienced personnel willing to risk radiation exposure, available materials, and full support of a nation willing to risk failure, the time could be short.

THE SECRECY ISSUE

If secrecy can be maintained, how quickly a nonnuclear-weapons nation could build and operate a secret reprocessing plant is relatively unimportant. The Oak Ridge memorandum did not address whether the reprocessing plant could be secretly built and operated. Dr. Laney of Argonne National Laboratory and Mr. Taylor of Westinghouse Electric Corporation, however, contended that the central point of the Oak Ridge memorandum was that secret construction is technically feasible and could present a detection problem for intelligence agencies.

We attempted to meet with CIA officials to determine how extensive a problem it is to detect the secret construction of a reprocessing plant in a nonnuclear-weapons nation, but they declined to meet with us. According to a CIA official such a meeting would not be appropriate because discussion of the issues might reveal the Agency's sources, methods, and capabilities.

Constructing the reprocessing plant is not the only step which risks detection. According to DOE the risk of detection would begin when a nation decides to acquire plutonium for a nuclear device from a secret reprocessing plant and would include all, or most, of the following steps

- the political decision to develop a nuclear explosive device;
- the decision to use a secret reprocessing facility as the preferred route;
- planning for the overall operation;
- the design and planning of the reprocessing facility;
- the acquisition of needed materials, equipment, and personnel;
- the construction of the reprocessing facility;
- possible equipment testing;
- design and prefabrication of the nuclear explosive device (minus the plutonium);
- diversion of the spent fuel;
- transport of the spent fuel to the reprocessing facility;
- reprocessing the spent fuel;
- conversion of the plutonium to a suitable form;
- fabrication of the nuclear explosive devices; and
- possible testing of the devices which would require advance preparation of a test site.

DOE believes that it is impossible to make any general statements about the probability of detection of the overall operation by intelligence or international safeguards. However, DOE noted that each new step involves an expanded number of people who know of the plan and hence increases the risk of detection; each new operation also involves the potential for unforeseen incidents which may cause disclosure. The Arms Control and Disarmament Agency and the Department of State believe, as indicated below, that undetected operation of a secret reprocessing plant is unlikely:

- A secret reprocessing plant would have a high probability of being detected, and in many cases this could constitute a substantial deterrent. (Department of State.)
- Using spent nuclear fuel to test or operate a secret facility would, in most cases, violate an international safeguards agreement. Major diversions of such fuel would be very difficult, if not impossible, to carry out without detection by international safeguards. While some unsafeguarded facilities producing spent fuel do exist, such facilities would not be a significant source of spent fuel which secret plants would be designed to process. (Arms Control and Disarmament Agency and Department of State.)
- The detection system of the International Atomic Energy Agency (IAEA) ^{1/} is designed to provide timely warning of the diversion of spent fuel. The IAEA goal for detection of a diversion of spent fuel is 2 to 3 months. This goal is a reflection on the possibility of a successful secret reprocessing operation. (Department of State.)
- The risk will always remain that warning may not be received until the first substantial diversion of spent fuel. It has always been recognized and accepted that should secret reprocessing plants be detected, political and diplomatic measures to counter such a situation would have to be instituted in a relatively short period of time. The political risks resulting from detection provide a strong deterrent. Upon discovery, a supplier nation would have little recourse but to respond with strong, unequivocal action. (Arms Control and Disarmament Agency.)

Although a substantial risk of detection may exist, there are limitations in the scope and applicability of international safeguards which must be recognized. For example, IAEA's

^{1/}IAEA is an autonomous organization of 110 member nations of the United Nations founded in 1957 to promote nuclear energy for the benefit of mankind without contributing to any military purposes. It has assumed primary responsibility for administering international safeguards designed to detect diversions of nuclear materials for unauthorized purposes.

safeguards system consists of material accountability, onsite inspections, and surveillance and containment devices such as cameras and seals. The principle is that the system's detection capability will deter a nation from diverting nuclear materials from intended peaceful purposes. IAEA's safeguards system, however, does not include the physical protection of spent fuel nor the monitoring of its transport, and IAEA does not have the authority to seek out secret nuclear facilities and cannot pursue or retrieve diverted spent fuel.

Further, although the nuclear facilities of most nonnuclear-weapons nations are subject to IAEA safeguards, there are some notable exceptions such as India, Israel, and South Africa. Each of these nations has one or more nuclear facilities not subject to IAEA safeguards, and none are parties to the Treaty on the Non-Proliferation of Nuclear Weapons. 1/

While there is a risk of detection for nuclear facilities where international safeguards are applied, its deterrent value in preventing national diversion of spent fuel is not clear. One reviewer, Mr. Gilinsky of the Nuclear Regulatory Commission, questioned the adequacy of IAEA's safeguards system for detecting national diversion of spent nuclear fuel and cautioned against relying too heavily on it for detecting potential diversions. He noted a recent IAEA report 2/ which reveals that, under practices existing in 1976, a diversion of spent fuel could have been accomplished without timely detection and conceivably without any detection at all.

In addition, we noted in a previous report to the Congress that the real effectiveness of IAEA safeguards is not known. 3/ At that time, U.S. and IAEA officials generally conceded that a country could circumvent safeguards if it was willing to assume the risk of detection, incur the expense, and take the trouble to do so. However, since the time of our review of IAEA many steps have been taken to improve the effectiveness of international safeguards by the United States, IAEA, and other nations.

1/Nonnuclear-weapons nations which are parties to the Treaty are committed to not manufacture or acquire nuclear weapons and to subject all peaceful nuclear facilities to IAEA safeguards.

2/The "Special Safeguards Implementation Report," released to member countries in 1977.

3/"Role of the International Atomic Energy Agency in Safeguarding Nuclear Material," (ID-75-65, July 3, 1975).

CONCLUSIONS

We believe that without time constraints many nonnuclear-weapons nations have or could acquire the technical capability to build and operate a reprocessing plant similar to that envisioned in the Oak Ridge memorandum, and could recover weapons-usable plutonium from spent nuclear fuel. Although we were unable to reduce the general uncertainty in the time range represented by the Oak Ridge memorandum's 4 to 6 months and the Congressional Research Service's 24 to 30 months, we believe the 4- to 6-month estimate, while not highly probable, should be considered credible in some circumstances. Further, although a substantial risk of detection may accompany a national decision to build and operate a secret reprocessing plant, there are limitations in the scope and applicability of some detection activities, and the deterrent value of these activities is not clear.

CHAPTER 3

WHAT ARE THE POLICY IMPLICATIONS?

The U.S. policy on nuclear nonproliferation is intended to limit the number of nations with nuclear explosive capabilities. While there are several ways a nation could obtain the essential nuclear materials needed for nuclear explosive devices, ¹/ current U.S. policy focuses heavily on discouraging the worldwide spread of reprocessing facilities which would provide direct access to plutonium. Access to plutonium, or even the capability to recover it from the spent fuel of nuclear powerplants, can lead to the risk that plutonium would be used for nuclear explosive devices.

U.S. POLICY TOWARD REPROCESSING

In the past the United States has 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 easily use such "sensitive" technology to make weapons.

Although the United States had never exported reprocessing facilities and, according to DOE, had never transferred significant reprocessing facilities abroad, the United States subsequently evolved a nuclear policy designed to discourage the worldwide spread of reprocessing facilities. In general, the basic elements of this policy are to:

- Defer indefinitely reprocessing of spent fuel in the United States.
- Continue to refrain from exporting reprocessing technology and encourage other nuclear supplier nations to do likewise.

¹/The essential nuclear materials are those which will sustain a nuclear fission chain reaction--plutonium, highly enriched uranium or uranium-233. Appendix I provides an overview of the various ways a nation could acquire these materials.

- Maintain and extend U.S. rights to approve any foreign reprocessing of U.S.-supplied fuel, or fuel not supplied by the United States but irradiated in U.S.-supplied reactors.
- Seek an international consensus on technical and institutional means to minimize the risk of the further proliferation of nuclear weapons capabilities associated with reprocessing.
- Improve existing controls and international safeguards on spent fuel to deter its national diversion.

This policy is based in part on the administration's position that in relation to proliferation reprocessing should be considered a step which distinguishes between relatively safe and dangerous operations of nuclear power systems. Current nuclear power systems, so-called once-through fuel cycles, where spent fuel is stored rather than reprocessed, are considered much more proliferation resistant than systems using or requiring reprocessing.

The reason for this distinction is straightforward. Direct access to plutonium is not provided in current once-through fuel cycles whereas conventional reprocessing facilities would provide direct access to plutonium. Because of this direct-access capability and widespread doubts about whether reprocessing facilities can be adequately safeguarded to prevent national diversion of separated plutonium, the existence of reprocessing facilities and the resultant large stocks of separated plutonium could permit a nation to fabricate nuclear explosives within a very short time--possibly days, with prior planning. In addition, the presence of large inventories of separated plutonium from reprocessing facilities increases the risk of theft by terrorists.

THE RELATIONSHIP BETWEEN THE OAK
RIDGE MEMORANDUM AND U.S. POLICY
TOWARD REPROCESSING

The Oak Ridge memorandum does not address its implications for U.S. policy toward reprocessing. However, because it raises the possibility of quick construction of secret reprocessing facilities in nonnuclear-weapons nations, it has been used to question whether reprocessing should be considered a step that distinguishes between relatively safe and dangerous operations of nuclear power in relation to proliferation.

The contention is that if quick construction of secret facilities were highly probable then it would blur the distinction between nuclear power based on storage of spent fuel and nuclear power based on reprocessing of spent fuel, because the proliferation risks of spent fuel in storage would more nearly approach those of reprocessing. Therefore, according to this argument, there might be less reason for the United States to discourage reprocessing.

As indicated by the following comments, the Arms Control and Disarmament Agency, DOE, and the Department of State believe the possibility of quick construction of a secret reprocessing facility does not support the need for any basic changes in U.S. policy toward reprocessing.

--The option of building a "simple and quick" reprocessing plant as a means of obtaining weapons-usable plutonium has been available to at least some countries for more than a decade, yet in most or all cases countries have not chosen to exercise that option. (Department of State.)

--Secret reprocessing plants do not have a high probability of success nor a high probability of going undetected. (Department of State.)

--Despite the possibility of secret plants, once-through fuel cycles substantially increase delays and risks in obtaining weapons-usable plutonium when compared to any fuel cycle involving reprocessing. Thus, regardless of how quickly a secret plant could be built basic nonproliferation objectives are served by the deferral of reprocessing. (Department of State, Arms Control and Disarmament Agency.)

--The Oak Ridge memorandum can be interpreted to support U.S. policy toward deferral of reprocessing in that (1) a secret reprocessing operation is less likely to be detected against a background of widespread reprocessing and (2) assurance of success could be enhanced under a widespread reprocessing environment because the technicians, equipment, and infrastructure are much more likely to be available than in the case of once-through systems. (DOE)

We believe the possibility of quick construction of secret reprocessing plants is not a significant factor in a decision on whether to allow reprocessing of spent fuel. Secret plants do not have a direct relationship to the spread

of legitimate reprocessing plants, which are the primary focus of U.S. policy. In our view, the further spread of legitimate reprocessing plants without assurances they would be adequately safeguarded clearly presents greater proliferation risks than, and is a separate issue from, the possibility of secret reprocessing plants.

Legitimate plants, unlike secret plants, would probably be large and subject to international safeguard controls and inspection. However, legitimate plants could provide a cover for the recovery of enough plutonium for a large number of nuclear weapons, and in the event of abrogation of safeguard agreements there would be minimum warning time. Secret plants, on the other hand, might provide greater warning time because the risk of detection would begin before construction started. Clearly, two different threats and circumstances are involved.

U.S. INITIATIVES TO IMPROVE CONTROLS ON SPENT FUEL

An additional policy concern is the need for improved controls on spent fuel to deter its national diversion. Because many nonnuclear-weapons nations have or could acquire the technical capability to build and operate small reprocessing plants, the Oak Ridge memorandum serves to reemphasize the importance of deterring national diversion of spent fuel to such plants.

The United States recognizes the importance of this concern and has recently taken action addressing it. Among the most important actions are:

- Provisions in the Nuclear Non-Proliferation Act of 1978 (Public Law 95-242, March 10, 1978) which require the United States to (1) improve the IAEA safeguards system to ensure the timely detection of possible diversions of nuclear materials which could be used for nuclear weapons, (2) terminate any further exports of nuclear supplies to a nonnuclear-weapons nation which (a) detonates a nuclear explosive device regardless of the source of materials or (b) terminates, abrogates or violates IAEA safeguards, (3) condition U.S. nuclear exports so that spent fuel derived from such exports cannot be reprocessed without U.S. approval, and (4) encourage nonnuclear-weapons

nations to adhere to the Treaty on the Non-Proliferation of Nuclear Weapons. 1/

- DOE received an appropriation of \$5 million for fiscal year 1978 (Public Law 95-96, Aug. 7, 1977) to (1) conduct multinational or international studies on the feasibility of expanding existing worldwide spent fuel storage capacity and (2) enter into agreements with other nations, subject to congressional consent, for providing appropriate support to increase multinational or international storage capacity.
- Initiation of the International Fuel Cycle Evaluation, which is a broad-base international study of how best to proceed with the development of nuclear power while minimizing the risk of proliferation of nuclear weapons. A large portion of this evaluation is being devoted to studying technical and institutional methods for the storage and reprocessing of spent fuel.
- DOE development of a comprehensive plan on the technical means for timely detection of spent fuel diversion. This plan is technical, and DOE hopes to integrate it during the implementation stage with proposals expected to evolve from the International Fuel Cycle Evaluation for institutional arrangements to control spent fuel worldwide.

ASSURANCES ON A COUNTRY-BY-COUNTRY BASIS

Up to this point we have addressed in general terms the possibility of nonnuclear-weapons nations quickly constructing a secret reprocessing plant. Because many nonnuclear-weapons nations have or could acquire the technical capability to build and operate a reprocessing plant, it is important that the United States, on a country-by-country basis, have sufficient assurances that such nations have no intentions to divert U.S.-supplied nuclear materials to secret reprocessing facilities. The Nuclear Non-Proliferation Act of 1978 calls for such kinds of assurances.

Primary responsibility in the executive branch for providing these assurances rests with the Departments of State, Defense, and Energy, and the intelligence community. Further,

1/The act also requires us to complete a study and report to the Congress on the act's implementation and impact by March 10, 1981.

before granting nuclear export licenses to nonnuclear-weapons nations, the Nuclear Regulatory Commission is responsible for conducting an independent review of these assurances. In a draft of this report, we made the point that in carrying out its responsibilities the Nuclear Regulatory Commission should pay particular attention to the latest intelligence information on recipient nations' intentions and activities toward a potential secret reprocessing operation.

Commenting on our report, the Nuclear Regulatory Commission agreed that foreign intelligence information is needed to properly carry out its responsibilities for licensing the export and import of nuclear materials and facilities. The Commission stated that in 1976 contacts with the intelligence community, including CIA, were initiated to establish the types of intelligence information required, and this action resulted in the Commission receiving relevant intelligence information on a regular basis. In addition, the Commission stated their needs were reaffirmed and reemphasized to CIA following enactment of the Nuclear Non-Proliferation Act of 1978, and the flow of requested intelligence information is being updated and maintained on a continuing basis. CIA commented that intelligence information on the technical aspects of foreign nuclear programs has been sent routinely to the Commission for some time, and recently this information has been supplemented by relevant political and economic intelligence.

CONCLUSIONS

We believe the possibility of quick construction of secret reprocessing plants is not a significant factor in a decision on whether to allow reprocessing of spent fuel. Secret plants do not have a direct relationship to the spread of legitimate reprocessing plants, which are the primary focus of U.S. policy. In our view, the further spread of legitimate reprocessing plants without assurances they would be adequately safeguarded clearly presents greater proliferation risks than, and is a separate issue from, the possibility of secret plants.

The Oak Ridge memorandum, however, reemphasizes the importance of deterring national diversion of spent fuel to such plants. The United States recognizes the importance of this concern and has recently taken action addressing it. Although it is too early to say how successful these actions will be, we will be evaluating the implementation and impact of these actions on U.S. nonproliferation policy in response to a mandate of the Nuclear Non-Proliferation Act of 1978.

POTENTIAL ROUTES TO NUCLEARWEAPONS MATERIALS

There are several ways a nation could obtain plutonium, uranium-233, or highly enriched uranium--the essential nuclear materials needed for nuclear explosive devices. This report has examined the credibility and policy implications of one potential route, the use of a small and secret reprocessing facility to obtain plutonium from spent nuclear fuel diverted from commercial powerplants. This appendix provides an overview of other potential routes.

A recent report by the Office of Technology Assessment (OTA) assessed the risk of the further spread of nuclear weapons. ^{1/} We know of no comparable assessment conducted by any executive branch; hence, the OTA report is the latest and most comprehensive Government assessment of potential proliferation routes. According to the report, a nation planning the development of nuclear weapons has several basic options for obtaining weapons-usable materials. It could (1) construct and operate facilities specifically dedicated to its production, (2) divert the material from research reactors, (3) divert the material from commercial nuclear power facilities, or (4) steal or purchase the material.

DEDICATED PRODUCTION FACILITIES

Two basic options are available to a nation using this route. It could construct and operate

- a plutonium-production reactor and a reprocessing plant to separate the plutonium from the spent fuel or
- an enrichment plant to produce highly-enriched uranium from natural uranium.

The desired size of the weapons program is a crucial factor in determining how attractive a particular kind of dedicated facility would be to any nation. In general, an

^{1/}"Nuclear Proliferation and Safeguards," June 1977. OTA was created in 1972 as an advisory arm of the Congress. Its role is to provide the Congress with independent information about the potential effects of technological applications.

assessment of the attractiveness requires estimating cost, time, and personnel requirements. Important factors affecting the estimates are the available natural resources, the technological and industrial base, the number of trained scientists and engineers, and the labor cost. All nations now known to have nuclear weapons initially obtained the materials from facilities specifically dedicated to its production.

Plutonium production facilities

A country wanting a small weapons program might only need a small plutonium production reactor and reprocessing plant. OTA estimated that a reactor producing enough plutonium for one or two explosives annually could be built in about 3 years and be operated by a small number of experienced, competent professional engineers at a cost of \$15 million to \$30 million.

OTA estimated that a small reprocessing plant to separate plutonium from spent fuel of a plutonium production reactor could be built for less than \$25 million. According to OTA the fuel rods containing the plutonium would be easier and less hazardous to handle than the fuel rods from a commercial nuclear powerplant. The possibility of building and operating a small reprocessing plant for commercial powerplant spent fuel is discussed in chapter 2.

According to OTA many developing countries with a modest technical infrastructure now have the capability to build and operate small plutonium production and reprocessing facilities. However, only countries with a high level of industrialization and a considerable nuclear base would find large plutonium production and reprocessing facilities attractive for an ambitious weapons program (10 to 20 explosives per year). OTA estimated that a large reactor and reprocessing plant could be built in 5 to 7 years and operated by 200 to 275 engineers and skilled technicians at a cost of \$175 million to \$350 million.

Enrichment facilities

Once a nation has enrichment capacity it can produce highly enriched uranium for weapons. Several production methods might be considered by a nation desiring a nuclear explosive capability. The methods include gaseous diffusion, Becker nozzle, gas centrifuge, and more advanced enrichment methods.

The prevailing enrichment method is gaseous diffusion. It was developed during World War II and has remained, until recently, essentially the only source of enriched uranium. There are presently seven known gaseous diffusion plants in the world. They are located in countries with well-developed nuclear weapons capabilities. (Three are located in the United States and one each in the United Kingdom, France, China, and the Soviet Union.) Gaseous diffusion plants are so expensive and technologically complex that their construction and operation is feasible only for highly developed countries.

The Becker nozzle process is also very expensive and technologically complex. A nozzle enrichment facility is being sold to Brazil by West Germany, and a variation of it is being developed in the Union of South Africa.

Centrifuge enrichment was researched during World War II but it was later abandoned. The technique reemerged and has now reached advanced development in this country; it is being used commercially in Europe. It may be the cheapest present method, using far less power and having the potential of modular operation; that is, small groups of centrifuges can operate as soon as they are built and tested without awaiting the completion of a large facility.

According to OTA, a small centrifuge enrichment operation is only likely to be built as an add-on to an existing plant. For a nation desiring only a small weapons program (one or two explosives a year) OTA estimated the capital costs for such an operation to be \$2 million to \$5 million. To produce enough highly enriched uranium for a large weapons program (10 to 20 explosives per year) OTA's capital cost estimate was \$120 million to \$240 million for a "stand-alone" plant. These estimates do not include research and development costs. Such costs would have to be added because centrifuge enrichment is a difficult technology and is closely protected by the few nations which have it.

A number of advanced enrichment techniques are being investigated that may allow highly enriched uranium to be produced more cheaply. Two laser techniques and a plasma process are being investigated by DOE. All three processes

--are in the research or early development stage,

--promise to extend uranium resources,

- promise to lower the cost of enrichment, and
- build on a high-technology base.

According to OTA, advanced enrichment processes also have the potential for exacerbating the problem of nuclear proliferation because of their possible future use on a small scale. The level of proliferation risk will depend on whether

- the technology can remain tightly and effectively classified,
- the technology would be sold by one or several countries after development,
- other nations have the capability to replicate successful commercial designs, and
- an effective safeguard system can be developed to detect secret production or diversion of highly enriched uranium in a commercial enrichment facility.

Commenting on our report, DOE said it is not clear that advanced enrichment techniques have the potential for exacerbating the problem of nuclear proliferation. According to DOE, recent evaluations indicate that because of the advanced technology that is required to implement any of the three processes under development, only those countries which are technically advanced could either develop an intrinsic advanced enrichment capability or modify an existing low enriched uranium plant for production of weapons-usable material. DOE said that if this proves to be the case upon further analysis, the use of advanced enrichment technology would not exacerbate the problem of nuclear proliferation.

RESEARCH REACTORS

More than 300 research reactors operate around the world. However, not all of these are capable of producing enough useful material for a nuclear weapon. Further, a nation diverting plutonium from a research reactor would need a reprocessing plant similar to that associated with a plutonium production reactor. OTA estimated there are 18 countries with research reactors having the potential of

- producing enough plutonium for one or more weapons by 1984 and/or

--requiring sufficient highly enriched uranium to provide, if diverted, material for one or more weapons by 1984.

The Westinghouse Electric Corporation has estimated there are nine nonnuclear-weapons countries which now are able to produce sufficient plutonium from research reactors for one or more nuclear weapons a year. These include two research reactors located in India and Israel, which are not safeguarded by the International Atomic Energy Agency.

India is the only nation known to have used material from a research reactor. On May 18, 1974, India exploded a nuclear device using plutonium produced in a Canadian-supplied research reactor and separated from spent fuel in a small reprocessing facility. Since that time, India has not conducted any other tests and reportedly has agreed not to do so.

COMMERCIAL NUCLEAR POWER FACILITIES

No nation known to have nuclear weapons obtained them by extracting the needed material from its commercial nuclear power system, but it is possible for a nation to do so. Major factors involved in the decision to divert material from commercial facilities include the number and location of potential diversion points in the system, the amount and usefulness of the material diverted, and the objectives of the divertors. Based on a qualitative evaluation of these factors, OTA ranked the proliferation resistance of 10 reactor systems for four general categories of proliferators:

- (1) Nations desiring a major nuclear weapons force.
- (2) Nations desiring a small, not necessarily sophisticated, nuclear capability.
 - a. Facilities not safeguarded.
 - b. Facilities safeguarded.
- (3) Nations desiring the option of rapid development of nuclear weapons in the future should that appear necessary.
- (4) Nonstate adversaries (terrorists or subnational groups).

The results of OTA's analysis are shown on the table on the following page.

Reactor Systems Resistance to Proliferation

Reactor System	Availability	1. Major Force	2a. Small Force (unsafeguarded facilities)	2b. Small Force (safeguarded facilities)	3. Option	4. Non-State Adversaries
Light Water Reactor (enrichment)	Present	5	6	7	1	1
Light Water Reactor (spent fuel)	Present	4	3	1	4	4
Light Water Reactor (reprocessing & recycle)	Present	6	5	8	5	6
CANDU (heavy water reactor)	Present	8	7	2	2	2
High Temperature Gas Reactor	Near Term	7	4	6	6	7
Advanced Gas Reactor	Near Term	3	2	3	3	3
Liquid Metal Fast Breeder Reactor	R&D (advanced)	9	^{a/} 9	9	9	9
Gas Cooled Fast Reactor	R&D	10	^{a/} 10	10	10	10
Light Water Breeder Reactor	R&D	1	1	4	7	8
Molten Salt Breeder Reactor	R&D (presently inactive)	2	^{a/} 8	5	8	5

^{a/} May not be an option for cost or technological reasons.

SOURCE: OTA

OUR NOTE: Ranked in order of relative diversion potential with "10" representing the greatest diversion potential and "1" the least.

OTA's evaluation shows the difficulty in deciding which reactor system would be the best, from the standpoint of resistance to the proliferation of nuclear weapons, for the United States to use and export to other nations. The liquid metal fast breeder reactor and the gas cooled fast reactor clearly have the greatest diversion potential in all categories, because of the large quantities of excess plutonium produced. However, no general statement can be made about the proliferation resistance of all reactor systems for all categories of divertors. 1/

Originally, resistance to proliferation was not an explicit criterion in the design of nuclear power systems. Presidents Ford and Carter have now made it a primary criterion. As a result, many proposals have been made and some experimental work is being conducted to make the reactor systems OTA evaluated more proliferation resistant. Further, other reactor systems have been proposed.

PURCHASE OR THEFT

No information is publicly available that conclusively shows that any nation has purchased or stolen nuclear material to make weapons. However, if technologically less developed nations and terrorists or other subnational groups were to do so, they could bypass the need for expensive and demanding technologies.

If weapons-usable materials were to become routinely traded in international commerce, then purchase or theft would become more attractive. Such materials might be acquired illegally in what is termed a "black market," or secretly bought or traded from a friendly nation in what is termed a "gray market."

1/Commenting on our report, the Department of State and the Arms Control and Disarmament Agency disagreed with many of the assessments in the OTA table. CIA commented the table reflects a rather parochial view of reactor development, particularly in that liquid metal fast breeder reactors are presently in operation in a number of other countries. None of these agencies, however, provided us their assessment.