April 18, 1974

POLICY SESSION ITEM

For: The Commissioners

Thru: Director of Regulation

Subject: CONSIDERATION OF FORM FOR SHIPPING PLUTONIUM

Purpose: To consider publication of effective amendments to 10 CFR Part 71 to require that (1) plutonium in excess of twenty (20) curies per package be shipped as a solid; (2) plutonium in excess of twenty (20) curies per package be packaged so as to provide double containment of the contents, except for certain specified forms; and (3) existing approvals for shipment that do not meet the above conditions shall terminate four years after adoption of the amendments to Part 71.

Discussion: On August 1, 1973, the Commission published a notice of proposed rule making (38 FR 20482) that would have required that all plutonium in excess of twenty curies per package be shipped as a solid material contained within a "special form" capsule placed within a package meeting the conditions for normal form material. The effective date proposed was three years after adoption of the amendment.

A summary of the comments received, with the staff's evaluation, is attached as Enclosure "B". Twenty licensees, members of the general public, and other Government agencies submitted comments; ten expressed from complete to some degree of approval, four objected to the rule, and six offered comments without expressing approval or disapproval. As was noted in SECY-R-702,* one fabricator of mixed oxide fuel would have to redissolve the plutonium because of process incompatibility. It should be noted, however, that this licensee's comments did not specifically address the question of process incompatibility. The General Manager and eleven AEC or AEC contractor organizations offered comments; seven expressed from complete to some degree of approval, one objected completely to the rule (the Richland Operations Office), and four offered comments without expressing approval or disapproval.

*Secretariat Note: SECY-R-74-702 - Consideration of Form for Shippin Plutonium, issu-d June 1, 1973.

As a result of the comments received, three changes in the rule appear appropriate and are being recommended:

1. The requirement that the inner containment vessel must meet the "special form" capsule requirements has been replaced with a requirement that the inner containment vessel must be designed to maintain its integrity after the entire package has been subjected to the normal and accident test conditions prescribed by the regulations. The effect of the requirement is still double containment, but with less severe performance requirements for the inner container.

2. Solid plutonium in the following forms will be exempt from the double containment requirements because these are essentially nonrespirable: (1) reactor fuel elements; (2) metal or metal alloy, and (3) other plutonium bearing solids that the Commission determines suitable for such exemption, these would be other essentially nonrespirable forms of plutonium.

3. The implementation period will be extended from three to four years. The most frequent comment was to extend the three-year implementation period.

When the proposed rule was approved for publication, the staff stated that an environmental impact statement would be prepared. Consistent with recently published guidelines of the Council on Environmental Quality, we intend to make a Negative Declaration since the Staff's Environmental Impact Appraisal, attached as Enclosure "C", shows that there would be no significant impact on the quality of the human environment as a result of the rule making.

Issue: Should the Commission adopt regulatory requirements to enchance safety by requiring plutonium to be shipped as a solid, under double containment, thereby minimizing the likelihood of leakage during transport as a result of possible packaging errors? Existing package design and performance specifications in the regulations are considered adequate to assure against release of contents under accident conditions.

Recommendations: The Commission:

(a) Approve publication in effective form of the amendments to 10 CFR Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Materials under Certain Conditions," as set forth in Enclosure "A", that would require that (1) Plutonium in excess of twenty (20) curies per package be shipped as a solid; (2) plutonium in excess of twenty (20) curies per package be packaged so as to provide double containment of the contents with each containment designed to maintain its integrity when the entire package is subjected to the normal and accident conditions of Part 71. Reactor fuel elements, metal and metal alloys, and other solid materials as specifically approved by the Commission would be exempt from the double containment requirement; and (3) authority provided in AEC licenses which does not meet the foregoing requirements will expire four years after adoption of the amendments;

(b) Note that the staff has prepared a Negative Declaration of environmental impact, based on the staff's Environmental Impact Appraisal that determines that there is no significant environmental impact as a result of this rule making action;

(c) Note that the staff's Environmental Impact Appraisal will be available for public inspection at the Commission's Public Document Room;

(d) Note that a public announcement such as Enclosure "D" will be issued when the amendment is filed with the Office of the Federal Register.

Coordination: The Directorates of Regulatory Standards and Regulatory Operations, and the Office of General Counsel concur in the recommendations of this paper. The comments of the General Manager were considered in the preparation of this paper. The Office of Information Services prepared the draft public announcement, attached as Enclosure "D".

Commissioner Doub, the Lead Commissioner, and Commissioner Larson have been consulted on this paper and they advise that it is in a form suitable for Commission consideration.

Scheduling: Consideration of this paper at an early Policy Session is requested.

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Director of Licensing

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ENCLOSURE "A"

TITLE 10 - ENERGY

CHAPTER I - ATOMIC ENERGY COMMISSION

PART 71 - PACKAGING OF RADIOACTIVE MATERIAL FOR TRANSPORT AND TRANSPORTATION OF RADIOACTIVE MATERIALS UNDER CERTAIN CONDITIONS

Form for Shipping Plutonium

On August 1, 1973, the Commission published in the FEDERAL REGISTER a notice of proposed rule making (38 FR 20482) that would have required that all plutonium in excess of twenty curies per package be shipped as a solid material contained within a "special form" capsule placed within a package meeting the conditions for normal form material. The effective date proposed was three years after adoption of the amendment. All interested persons were invited to submit written comments and suggestions for consideration in connection with the proposed amendment within 60 days after publication of the notice of proposed rule making in the FEDERAL REGISTER. After careful consideration of the comments received and other factors involved, the Commission has adopted the amendments as published for comment with the following changes:

(1) The proposed requirement that the inner containment vessel meet the "special form" capsule requirement has been replaced with a requirement that the inner containment vessel must maintain its integrity after the entire package has been subjected to the normal and accident test conditions prescribed by Part 71. The effect of the

amended provisions is still to require double containment of the contents. A number of commenters expressed the view that while double containment of plutonium is an important safety objective, a requirement that the inner container meet the stringent performance specifications required of a "special form" capsule was unnecessary. The Commission considers it most important that solid form plutonium be doubly contained and that both barriers in the packaging maintain their integrity under normal and accident test conditions. The present packaging required for normal form material provides the outer barrier. In specifying the "inner barrier" in the proposed rule, the Commission proposed a form of encapsulation that was already defined in Part 71, with corresponding performance specifications. Since the inner containment requirements are intended to take into account the fact that the plutonium may not be in a "nonrespirable" form, the Commission has concluded that if it can be demonstrated that the inner container will maintain its integrity in the packaging after the package is subjected to the normal and accident test conditions, sufficient protection will be afforded.

(2) Solid plutonium in the following forms has been exempted from the double containment requirements: (a) reactor fuel elements; (b) metal or metal alloy; and (c) other plutonium bearing solids that the Commission determines suitable for such exemption. Since the double containment provision compensates for the fact that the plutonium may not be in a "nonrespirable" form, solid forms of plutonium that are essentially nonrespirable should be exempted from the

double containment requirement. Therefore, it appears appropriate to exempt from the double containment requirements reactor fuel elements, metal or metal alloy, and other plutonium bearing solids that the Commission determines suitable for such exemption. The latter category provides a means for the Commission to evaluate, on a case-by-case basis, requests for exemption of other solid material where the quantity and form of the material permits a determination that double containment is unnecessary.

(3) The implementation period has been extended from three to four years. Many comments suggested that the proposed three-year implementation period was not long enough, considering the necessary plant design effort, licensing, and construction of required facility modifications necessary to meet the requirements. Additional time was requested. The Commission believes that the increases in the amounts of plutonium to be shipped and the changing characteristics of plutonium will not change significantly in the next four years when compared to years beyond 1978. The four-year period for compliance should give the nuclear industry a sufficient period for implementation.

The Commission has determined, pursuant to guidelines of the Council on Environmental Quality, that this rule making action will not significantly affect the quality of the human environment, and has issued a Negative Declaration on environmental impact. The staff's environmental Impact Appraisal supporting this declaration is available for

public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C.

Pursuant to the Atomic Energy Act of 1954, as amended, and sections 552 and 553 of Title 5 of the United States Code, the following amendments to Title 10, Chapter 1, Code of Federal Regulations, Part 71, are published as a document subject to codification.

1. A new § 71.42 is added to read as follows:

§ 71.42 Special requirements for plutonium shipments after .*

(a) Notwithstanding the exemption in § 71.9, plutonium in excess of twenty (20) curies per package shall be shipped as a solid.

(b) Plutonium in excess of twenty (20) curies per package shall be packaged in a separate inner container placed within outer packaging that meets the requirements of Subpart C for packaging of material in normal form. The separate inner container shall not release plutonium when the entire package is subjected to the normal and accident test conditions specified in Appendices A and B. Solid plutonium in the following forms is exempt from the requirements of this paragraph:

(1) reactor fuel elements;

(2) metal or metal alloy; or

(3) other plutonium bearing solids that the Commission determines should be exempt from the requirements of this section.

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* Four years after publication in the Federal Register

(c) Authority in AEC licenses issued pursuant to this part for delivery of plutonium to a carrier for transport under conditions which do not meet the limitations of paragraphs (a) and (b) of this section shall expire on .*

Effective date. The requirements of this part are effective on (30 days after publication).

Dated at _____ this _____ day of _____ 1974.

For the Atomic Energy Commission

_____

Paul C. Bender
Secretary of the Commission

*Four years after publication in the Federal Register

Enclosure "A"

ENCLOSURE "B"

CONSIDERATION OF FORM FOR SHIPPING PLUTONIUM

COMMENTS ON PROPOSED RULE MAKING

STAFF EVALUATION

The Regulatory staff has evaluated the comments received from licensees, other government agencies, private citizens, citizen groups, and other organizations within the Atomic Energy Commission in response to the notice of proposed rule making that appeared in the Federal Register on August 1, 1973. The proposed amendments would have required that all plutonium in excess of twenty curies per package be shipped as a solid material contained within a "special form" capsule placed within a package meeting the conditions for normal form material. The effective date proposed for implementation was three years after adoption of the amendment.

As a result of comments received, three significant changes in the rule are being considered:

1. The requirement that the inner containment vessel meets the "special form" capsule requirements will be replaced with a requirement that the inner containment vessel maintain its integrity after the entire package has been subjected to the normal and accident test conditions prescribed by the regulations. The effect of the requirement is double containment.
2. Solid plutonium in the following forms will be exempt from the double

containment requirements: (a) reactor fuel elements; (b) metal or metal alloy; and (c) other plutonium bearing solids that the Commission determines suitable for such exemption.

3. The implementation period will be extended from three to four years.

A number of persons, including the General Manager, expressed the view that while double containment of plutonium is an important objective, a requirement that the inner container meet the stringent performance specifications required of a "special form" capsule was unnecessary. The basic requirement that the staff feels is most important is that the solid form plutonium be doubly contained such that both barriers have demonstrated integrity under normal and accident test conditions. The present packaging for normal form material provides the outer barrier. In defining the inner barrier, the staff proposed a form of encapsulation that was already defined in the AEC regulations, with corresponding performance specifications. This seemed to provide the needed double containment. The purpose of the inner containment is to compensate for not requiring the plutonium to be in a "nonrespirable" form. Upon reconsideration, the staff feels that as long as it can be demonstrated that the inner container will maintain its integrity after being subjected to the accident and normal test conditions, while within regular packaging, sufficient protection will be afforded.

Since the double containment provision is in place of requiring a "nonrespirable" form, those forms of plutonium that are essentially

nonrespirable could be exempted from the double containment requirement. Therefore, in response to a number of comments in this regard, it appears appropriate to exempt reactor fuel elements, metal or metal alloy, and other plutonium bearing solids that the Commission determines suitable for such exemption, from the double containment requirement. This latter category is intended to provide a means for the Commission to evaluate, on a case-by-case basis, requests for exemption of such material as low level plutonium contaminated waste, where the quantity and form of the material would permit the Commission to determine that double containment was not necessary.

The most frequent comment was that the proposed three-year implementation period was not long enough considering the necessary plant design effort, licensing, and construction required. Additional time was requested. The three-year period was judged by the staff to be the shortest time in which the proposed requirements could be met, and thus was proposed. The importance of the effective date of the change is based on when anticipated increases in the plutonium shipping will occur. Staff believes that a four-year implementation period will coincide with an increase in plutonium utilization and, coupled with the expected time between the notice of Commission intent and adoption of effective rules, give industry about four and one-half years for implementation.

A discussion of comments submitted by licensees and the general public follows. Of twenty respondents, ten expressed some degree of approval, four

objected completely to the rule, and six offered comments without expressing approval or disapproval. Each specific comment is discussed, showing the respondents who made the comment, the staff analysis of the comment, and any resulting change in staff position. There were no environmental issues raised.

The most recent comments from the General Manager, submitted after concurrence in the staff paper that recommended publication of the proposed rule for public comment, are discussed, following the comments from licensees and the general public. Of twelve AEC offices and contractor organizations responding, seven expressed some degree of approval, one objected completely to the rule, and four offered comments without expressing approval or disapproval.

In summary, the Regulatory staff feels that the contemplated changes will reduce or eliminate most of the problems expressed by the comments without significantly affecting the objective of the proposed rule, i.e., to provide enhancement of safety in the shipment of plutonium.

The revised wording being considered for the final rule follows:

§ 71.42 Special requirements for plutonium shipments after .*

(a) Notwithstanding the exemption in § 71.9, plutonium in excess of twenty (20) curies per package shall be shipped as a solid.

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* Four years after adoption of this amendment

(b) Plutonium in excess of twenty (20) curies per package shall be packaged in a separate inner container placed within outer packaging that meets the requirements in Subpart C for packaging of material in normal form. The separate inner container shall be demonstrated to maintain its integrity when the entire package is subjected to the normal and accident test conditions specified in Appendixes A and B. Solid plutonium in the following forms is exempt from the requirements of this paragraph:

(1) reactor fuel elements;

(2) metal or metal alloy;

(3) other plutonium bearing solids that the Commission determines should be exempt from the requirements of this section.

(c) Authority in AEC licenses issued pursuant to this part for delivery of plutonium to a carrier for transport under conditions which do not meet the limitations of paragraphs (a) and (b) above shall expire on .*

*Four years after adoption of this amendment

SPECIFIC COMMENTS

FROM INDUSTRY AND GENERAL PUBLIC

COMMENT: Three years is not sufficient time for implementation, considering the necessary plant designs, licensing, and construction necessary for practical implementation. Additional time, up to five years before implementation, is suggested.

COMMENTERS: Yankee Atomic Electric Company
Westinghouse Electric Corporation
Exxon Nuclear Company, Inc.
General Electric Company
Allied-Gulf Nuclear Services
Gulf United Nuclear Fuels Corporation
Nuclear Materials and Equipment Corporation

STAFF EVALUATION: The need for the requirement is based on anticipated increases in the amounts of plutonium to be shipped and changing characteristics of plutonium. Staff recognizes that neither of these factors is likely to change significantly in the next four years when compared to years beyond 1978. The arguments presented by the affected licenses seem reasonable. By the time the rule would be adopted, industry would have about four and one-half years from the Commission's declaration of intent to prepare.

RESULTING CHANGES: The effective date of the proposed rule could be changed from three years after adoption to four years.

COMMENT: The proposed rule does not seem to be justified on the basis of safety. Past experience has shown that liquids can be shipped safely. A predetermined position by the Commission is arbitrary and unaccommodating Technical studies have not shown that one form is preferable over another.

COMMENTERS: Department of Transportation
Westinghouse Electric Company
General Electric Company
Kerr-McGee Corporation
David R. Smith

STAFF EVALUATION: As was stated in SECY-R-74-5, the arguments for requiring a solid form of plutonium for shipment are largely subjective, in that there is no hard evidence on which to base statistical

probabilities or to assess quantitatively the incremental increase in safety which is expected. The discussion in the Regulatory staff paper, SECY-R-702, is not intended to be a technical argument which incontrovertibly leads to the conclusion. It is, rather, a presentation of the rationale which has led the Regulatory staff to its conclusion that human error is more likely to cause a leak with a liquid than a solid and that the proposed action is a step towards increased assurance against the problem developing. The arguments presented are not new; such arguments were considered in developing the proposed amendments.

RESULTING CHANGES: None

COMMENT: While in agreement with the advantages of double containment, it does not seem necessary that the inner containment have the special characteristics of a "special form" capsule, i.e., able to withstand the effects of a 30-foot drop, ten minutes of high temperature, percussion and immersion tests.

COMMENTERS: Nuclear Fuel Services
David R. Smith
Allied-Gulf Nuclear Services

STAFF EVALUATION: The basic requirement that the staff feels is most important is that the plutonium be doubly contained such that both barriers have demonstrated integrity under normal and accident test conditions. The present packaging for normal form material provides the outer barrier. In defining the inner barrier, the staff chose a form of encapsulation that was already defined in the AEC regulations, with corresponding performance specifications. This seemed to provide the needed double containment. The need for the inner containment is based on the desire to provide a substitute for not requiring the plutonium to be in a "nonrespirable" form. Upon reconsideration, the staff feels that as long as it can be shown that the inner container has maintained its integrity after being subjected to the accident and normal test conditions, while in regular packaging, sufficient protection will be afforded.

RESULTING CHANGES: The proposed rule has been changed to eliminate the requirement that the plutonium be encapsulated in a "special form" capsule. Instead, the requirement will be that the plutonium be contained within a separate inner container that has been demonstrated leak tight after being placed in a normal form shipping container and subjected to the normal and accident test conditions.

COMMENT: Clarify the limits of applicability of the proposed amendment, insofar as it might apply to irradiated fuel elements containing plutonium.

COMMENTERS: Commonwealth Edison
State of New York Atomic Energy Council
Nuclear Fuel Services, Inc.
NL Industries

STAFF EVALUATION: The proposed rule would have applied to irradiated fuel elements as written. Irradiated fuel shipping casks are specifically evaluated with respect to fuel cladding integrity during transport, and appropriate safety features are incorporated where cladding integrity is not demonstrated. Therefore, double containment does not seem warranted.

RESULTING CHANGES: Reactor fuel elements (both irradiated and unirradiated) will be exempted from the double containment requirement.

COMMENT: Such restrictions as are imposed could better derive from functional performance standards rather than on arbitrary limits on product form. There are no insurmountable technical barriers that would preclude the development of acceptable packaging and thus justify an outright ban on shipment of plutonium in liquid form.

COMMENTERS: Exxon Nuclear Company, Inc.
General Electric Company
David R. Smith

STAFF EVALUATION: It is expected that packages can be designed to meet regulatory standards for either aqueous solutions or solid plutonium compounds. Just as in any situation involving the packaging of radioactive materials, a high level of human performance is necessary to assure against leakage caused by human error in packaging. As the number of plutonium shipments increases, as it will, and packages become larger and more complex in design, the probability of such human error increases. Should a human error occur in package preparation or closure, the probability of liquid escaping from the improperly prepared package is greater than for most solids and particularly for those solid plutonium materials expected to be shipped. For these reasons, staff feels that restriction to solid form is justified.

RESULTING CHANGES: None

COMMENT: Definition of "special form" and the limit for a Type A quantity of special form radioactive material in the 1973 revision of the IAEA regulations are inconsistent with those in the proposed rule. Recommend coordination with IAEA and DOT requirements.

COMMENTERS: Air Transport Association of America
Department of Transportation
Westinghouse Electric Company

STAFF ANALYSIS: Reference to the "special form" capsule will be deleted. Thus, the comments are no longer pertinent.

RESULTING CHANGES: "Special Form" requirement will be deleted.

COMMENT: Clarify the applicability of the proposed rule with respect to unirradiated fuel elements containing plutonium.

COMMENTERS: Nuclear Fuel Services, Inc.
NL Industries

STAFF EVALUATION: The rule would have applied to unirradiated fuel elements, as written. The usual fuel form is sintered oxide pellets that are refractory in nature and highly resistant to decomposition, contained within cladding that is designed to withstand the extreme environment of a nuclear reactor core. Thus, double containment proposed need not be required for this form of plutonium.

RESULTING CHANGES: Reactor fuel elements will be exempted from double containment requirement.

COMMENT: The basis for the breakpoint of 20 curies is not clear. How was this figure determined, and what isotopes are considered?

COMMENTERS: Air Transport Association of America
State of New York Atomic Energy Council

STAFF EVALUATION: It was felt that relief from the solid form and other requirements of the proposed rule should be provided to cover the shipment of analytical samples and research materials where solid form would be impractical and not necessary from a safety standpoint. The twenty-curie threshold was chosen because quantities in excess of this value represent a "large quantity" of plutonium, as defined in AEC and IAEA transport regulations. It is at this point that certain additional packaging requirements are imposed. Use of the twenty-curie threshold is

consistent with other parts of the regulations, e.g., the shipment of plutonium by passenger aircraft. The activity is determined by considering the total contribution of all plutonium isotopes present.

RESULTING CHANGES: None

COMMENT: An industry-wide standard for specification plutonium oxide must be adopted to avoid the need for further head-end treatment at the fuel fabricator.

COMMENTERS: Consolidated Edison Company of New York, Inc.
Yankee Atomic Electric Company

STAFF EVALUATION: The staff agrees and feels that suitable specifications can be adopted. Such a standard is being prepared by Committee C-26 of the American Society for Testing and Materials (ASTM).

RESULTING CHANGES: None

COMMENT: The proposed regulation fails to provide a procedure for exceptions for transport in liquid form in special cases. Future economics and safety analyses may lead to other forms and containers that should not be ruled out a priori.

COMMENTERS: General Electric Company
Nuclear Materials and Equipment Corporation

STAFF ANALYSIS: The regulations provide (§ 71.6) for the Commission to grant such exemptions from the requirements of the regulations as it determines are authorized by law and will not endanger life or property and the common defense and security. Such exceptions can be granted on a case-by-case basis, when it is shown that the requirements of § 71.6 are met. If future developments indicate a need for review of Commission policy, the proposed rule change would not prevent such consideration.

RESULTING CHANGES: None

COMMENT: It is most essential that high priorities be accorded the licensing of plutonium fuel fabrication facilities.

COMMENTERS: Exxon Nuclear Company, Inc.
Gulf United Nuclear Fuels Corporation

STAFF ANALYSIS: This problem should be alleviated somewhat by changing the effective date from three years to four years from adoption of the amendments. Nevertheless, the Regulatory staff recognizes the need to take actions to facilitate and expedite the licensing of critical fuel cycle facilities. The development of guides for the standard format and content of license applications, standardized internal review procedures, and guides to licensees for acceptable means of complying with regulatory requirements are all examples of means by which this is being done.

RESULTING CHANGES: None

COMMENT: Other radioactive materials such as Americium and Californium seem to be highly toxic as well. In establishing this proposal, were other equally toxic materials considered?

COMMENTER: Air Transport Association of America

STAFF EVALUATION: Consideration was given by the staff to a requirement which would have included all members of Transport Group I, the most hazardous radionuclides. This would have required such elements as Americium, Curium, etc., to be shipped in solid form. The basic argument of the need for solid form is that there will be large quantities of plutonium to be shipped in the future, thereby increasing the possibility for packaging errors. A similar increase in shipment of other elements in Transport Group I is not foreseen at this time. If such a trend develops, staff should reconsider the inclusion of other elements in the proposed requirement.

RESULTING CHANGES: None

COMMENT: We believe three years is too long to wait. Could this period be shortened under the current state of the art?

COMMENTER: Air Transport Association of America

STAFF EVALUATION: Practical implementation is dependent on the availability of oxide conversion facilities at the reprocessing plants and appropriate facilities at the fuel fabricators. Three years was judged by the staff to be the earliest possible time for implementation. The urgency for earlier implementation does not exist since the need for new requirements is based on anticipated future volumes of shipments and future characteristics of plutonium.

RESULTING CHANGES: None

COMMENT: Proposed regulation change might cause increased shipment of plutonium nitrate since nitrate presently in storage would have to be shipped to a convertor before the effective date.

COMMENTER: Consolidated Edison Company of New York, Inc.

STAFF EVALUATION: The New York Atomic and Space Development Authority (ASDA) plutonium storage facility to which Con Ed referred in their letter presently contains approximately 158 kilograms of plutonium nitrate in storage. Little more is expected to be put in this facility for some time because of the lack of reprocessing capability in the private sector. Thus, Con Ed's observation is valid, in that at least the 158 kilograms of plutonium presently stored at ASDA would have to be shipped to a conversion facility within the four years to be proposed as the effective date. The staff does not consider this to significantly increase the risks to health and safety.

RESULTING CHANGES: None

COMMENT: The Commission is risking another "as low as practicable" situation where it has undermined its own criteria, and has affected its credibility in the process. We see no indication that the transportation environment has altered such that existing hypothetical normal and accident conditions are no longer valid.

COMMENTER: Westinghouse Electric Company

STAFF EVALUATION: The staff does not agree that the proposed rule change is undermining the present criteria. Failure to add the proposed criteria could result in situations that would affect our credibility much more than any doubt brought about by taking the action. For example, any leakage incident that could have been prevented by requiring solid form rather than liquid would likely have a greater adverse effect on the Commission than will be caused by adopting a solid form requirement.

RESULTING CHANGES: None

COMMENT: The flexibility of shipping plutonium in either oxide or nitrate form is to be preferred for technical and economic reasons in fuel fabrication.

COMMENTER: Exxon Nuclear Company, Inc.

STAFF EVALUATION: The majority of opinions expressed by industry and AEC sources during discussions preceding the publication of the proposed rule concluded that oxide was the preferred form for receipt by the fuel fabricator. This was based on the economic advantage gained by centralized conversion by the reprocessor and the technical acceptability of a specification grade plutonium oxide for use by the fuel fabricator. If the fabricator has a need to redissolve and reconvert the plutonium, an obvious cost disadvantage occurs - the price paid for the special advantages the fabricator feels he has gained by the extra processing steps.

RESULTING CHANGES: None

COMMENT: Existing containers might be allowed to be used for solutions having a maximum alpha particle activity of something like 100 or 200 Ci per liter (approximately 200 g per liter of plutonium containing 6% plutonium 240 and 0.4% plutonium 241).

COMMENTER: David R. Smith

STAFF ANALYSIS: The four-year transition period should provide for most of the anticipated need for continued shipment of this type of plutonium solution in present containers. If a need for continued use beyond 1978 is demonstrated, the proposal can be examined on its merits and specific exemption, pursuant to § 71.6, 10 CFR Part 71, could be granted if the proper determination were made.

RESULTING CHANGES: None

COMMENT: Recommend that the shipment of flammable compounds of plutonium be prohibited as well as plutonium in powdered form.

COMMENTER: Natural Resources Defense Council, Inc.

STAFF EVALUATION: While there are no present restrictions, per se, on the shipment of flammable compounds, Part 71 requirements specify that the package shall be so designed and the contents so limited as to prevent the escape of any radioactive material after the package has been subjected to the normal and accident tests. Thus, the flammability of the contents must be considered in

determining whether the packaging is acceptable. The proposed rule attempts to compensate for not prohibiting the shipment of powder by requiring the double containment of the plutonium.

RESULTING CHANGES: None

COMMENT: We believe that the current L-10 container is adequate to withstand any pressurization due to the radiolytic action of plutonium. The exterior container contains sufficient absorbent material to retain three times the liquid volume of the inner container.

COMMENTER: Kerr-McGee Corporation

STAFF ANALYSIS: The staff does not agree that the L-10 container is adequate to withstand any pressurization. This, however, is not relevant to the argument of the proposed rule making, since the concern is not with rupturing of the pressure vessel because of pressure buildup, but with the presence of the pressure to act as a driving force to expel plutonium liquid in the event of a packaging error. The absorbent material in the L-10 is vermiculite and is placed there to act as a thermal barrier. No credit can be taken for its absorbency - in fact, such absorbtion could be of concern from a criticality standpoint.

RESULTING CHANGES: None

COMMENT: The shipment of solids would further constrain the development of improved technology thereby adding a fiscal burden to the fuel cycle industry.

COMMENTER: Kerr-McGee Corporation

STAFF ANALYSIS: The staff feels that the developing technology is favoring the use of oxide as the starting ingredient for the fuel fabricator and that there is an economical incentive to use this form of material generated by the fuel reprocessor. Thus, we do not agree with the respondent's contention.

RESULTING CHANGES: None

COMMENT: The measurements of quantities transferred in solids are much less accurate than that experienced with the transfer of liquids.

COMMENTER: Kerr-McGee Corporation

STAFF ANALYSIS: Staff does not agree with this contention. The oxide could be readily assayed by calorimetry, thus substantially reducing shipper-receiver differences. The nitrate is not readily assayed by calorimetry.

RESULTING CHANGES: None

COMMENT: The wording of the proposed rules is confusing and ambiguous.

COMMENTER: Westinghouse Electric Company

STAFF EVALUATION: Since only one person expressed this concern, it is not felt to be a general problem.

RESULTING CHANGES: None

DISCUSSION OF GENERAL MANAGER'S COMMENTS OF NOVEMBER 7, 1973

COMMENT: We agree with the basic concept of double-containment for shipment of plutonium in a concentrated dispersible form since it will provide a higher degree of assurance against operator error (and we have a program now underway to develop such package designs). We do not, however, agree with the idea that concentrated dispersible plutonium must be further protected by a third line of containment - "special form" encapsulation; and we vehemently disagree with the requirement that all plutonium, regardless of form or concentration have all three.

To require that massive plutonium metal, very low concentration plutonium contaminated solid waste and equipment, plutonium-bearing reactor fuel elements, and plutonium-bearing high level solid radioactive waste, even be doubly contained is not necessary from a safety standpoint, and to further require that materials of this nature be encapsulated into "special form" certainly cannot be justified.

STAFF ANALYSIS: If by "third line of containment" the GM means that there would be three barriers required, then there is a misunderstanding of the intent of the proposed rule. Packages for Type "B" quantities of plutonium presently require only one level of containment. The proposed rule would introduce a second containment barrier, the "special form" capsule. The staff intent was to provide double containment in the packaging of plutonium solids. The "special form" capsule was chosen since it was a form of encapsulation that was already defined in the AEC regulations, with corresponding performance specifications. The need for the inner containment is based on the desire to provide a substitute for not requiring the plutonium to be in a "nonrespirable" form. Upon reconsideration, the staff feels that as long as it can be shown that the inner container has maintained its integrity after being subjected to the accident and normal test conditions, while within regular Type "B" packaging, sufficient protection will be afforded.

Since the double containment provision is in place of requiring "nonrespirable" form, those forms of plutonium which are essentially nonrespirable could be exempted from the double containment requirement. The principal thrust of the requirement is aimed at plutonium oxide powder. The rationale for exempting reactor fuel elements is presented earlier. Since the concern is with minimizing possible leakage due to packaging errors, exemption of metal and metal alloys from the double containment requirement would be warranted in view of the relatively massive configuration in which they are shipped. Shipment would continue

to be in Type B packages. Waste materials packaged for disposal in Type B packages could be exempted because the usually dilute nature of solid waste would not constitute a leakage problem.

RESULTING CHANGES: The requirement for the inner container to be a "special form" capsule has been removed in favor of a general requirement for double containment. Specific exemptions from the double containment requirement for reactor fuel elements and metal have been added, along with a mechanism for approving an exemption on a case-by-case basis for other forms of plutonium (such as low level waste).

COMMENT: One other problem that has been raised by our study of the proposed regulation deals with the absolute prohibition of shipment of plutonium solutions (for greater than 20 Ci). This would prevent or at least seriously hinder the current practice of analytical sample exchange which is an important part of the U.S. and the international safeguards program.

STAFF ANALYSIS: In the preparation of the proposed rule, consideration was given to the need for some exempt quantity for plutonium shipments as liquids. There were suggestions that the rule be written to require solid form for all shipments of plutonium. This suggestion was rejected, because of the recognized need for transfer of analytical samples. The staff instead proposed a threshold limit of 20 curies, an activity level that is consistent with AEC and IAEA shipping requirements for "Large Quantity". Information provided by the Regulatory safeguards group in the Directorate of Regulatory Operations was that a 20-curie limitation would not place any undue burden on their shipments of inventory verification and other analytical samples.

There were no comments made from the private sector that their shipments of analytical samples would be affected, although a couple of respondents suggested that exceptions be granted in special cases for process development purposes. The regulations provide for the Commission to grant such exemptions from the requirements of the regulations as it determines are authorized by law and will not endanger life or property and the common defense and security. Through this mechanism, requests for shipments of liquids in excess of 20 curies will be evaluated on their particular merits.

Two of the AEC contractor organizations (New Brunswick Laboratory and Lawrence Berkeley Laboratory) responded to the General Manager that an outright prohibition of liquid shipments (which was not

proposed in the rule) would place an onerous burden on research facilities and the NBL analytical laboratory. These statements support the need for some exempt quantity.

The staff believes that the 20-curie threshold value for requiring solid shipment should not be changed. Requests for shipment of greater quantities of liquids should be evaluated on a case-by-case basis and special exceptions granted where warranted.

RESULTING CHANGES: None

COMMENTS OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

In December 1970, the Advisory Committee on Reactor Safeguards expressed to the Director of Regulation their keen interest in the subject of plutonium shipment and expressed a desire to be kept informed of developments from studies in progress. They expressed their belief that shipping plutonium in the liquid nitrate form presents sufficient potential hazard that steps should be taken to strongly encourage shipment of plutonium in the nonrespirable oxide form or in other solid form by 1975.

The ACRS was furnished with copies of the pertinent staff papers and they were discussed by the Environmental Subcommittee on January 31 and February 1. The Director of Regulation discussed the matter with the full committee on February 8. The ACRS had two comments to offer:

> They were in agreement that the proposed rule making was consistent with their earlier recommendations regarding the form for shipping.
>
> They suggested that the 20-curie threshold be defined as 20 alpha curies.

With respect to the latter comment, the intent would be to discount the contribution to total radioactivity from the plutonium-241 isotope, a relatively short-lived beta emitter, thereby permitting a greater quantity of plutonium to be shipped in the liquid form. In establishing a threshold value for requiring solid form for shipment, the staff felt that relief from the solid form and other requirements of the proposed rule should be provided to cover the shipment of analytical samples and research materials where solid form would be impractical and not necessary from a safety standpoint.

The 20-curie threshold was chosen because quantities in excess of this value represent a "large quantity" of plutonium, as defined in AEC and IAEA transport regulations. It is at this point that certain additional packaging requirements are imposed. Use of the 20-curie threshold is consistent with other parts of the regulations, e.g., the shipment of plutonium by passenger aircraft. The activity in these cases is determined by considering the total contribution of all plutonium isotopes present. There does not appear to be any compelling reason to do otherwise in this case at the present time.

ENCLOSURE C

ENVIRONMENTAL IMPACT APPRAISAL

CONCERNING PROPOSED AMENDMENTS TO

10 CFR PART 71 PERTAINING

TO THE FORM OF PLUTONIUM FOR SHIPMENT

SUMMARY

1. Description of Action

The proposed action concerns an amendment of the AEC regulations in 10 CFR Part 71 which would require that plutonium (in excess of 20 curies per package) be shipped as a solid encapsulated to meet the requirements of special form and that the requirement become effective three years after the date of adoption of the amendment. Based on the comments received on the Federal Register notice of August 1, 1973 (38 FR 20483), concerning the proposed rule making, the Staff is considering the possibility of specifying that packages provide at least double containment in lieu of the special form encapsulation as proposed and that certain solid forms of materials containing plutonium (such as reactor fuel assemblies, metal, metallic alloys and other solid materials as may be appropriate) not be subject to double containment provision. In addition, the proposed rule making may be made effective after a longer period of time such as four years following adoption, rather than three years as proposed. In the Staff's opinion, these modifications will still meet the basic objectives of the proposed rule making.

The existing regulations permit the shipment of plutonium in any chemical or physical form, including liquid plutonium nitrate. Plutonium nitrate solution is shipped from a fuel reprocessing facility to a fuel fabrication plant for conversion to the oxide form (a solid) and subsequent processing. The Staff believes the likelihood of plutonium leakage as a result of human error during preshipment operations would be substantially reduced and safety would be enhanced if the only permitted physical form of plutonium for shipment was a solid form, since solids are less susceptible to leakage. Under the proposed rule making, plutonium would be converted to a solid form, most likely the oxide, at the reprocessing facility and shipped to the various fuel fabrication plants for subsequent use. On the basis of the evaluation set forth in this statement and after weighing the environmental, technical, economic, safety and other benefits against environmental costs and considering available alternatives, it is concluded that, from the environmental viewpoint, tne benefits of the proposed amendment (including the possible modifications mentioned above) outweigh the costs. In fact, this assessment shows that there is no potential that the environment may be significantly affected as a result of the proposed rule. Consequently this document, originally intended as a draft environmental statement, has now been used in support of a determination that no impact statement need be prepared.

2. Summary of Environmental Impacts Including Adverse and Beneficial Environmental Effects

- Decrease in the risk of radiation exposure of the general population from shipment of plutonium.
- As a result of centralized conversion of plutonium nitrate to plutonium dioxide at fuel reprocessing facilities, there would be a decrease in the environmental impact from chemicals and radioactive materials at fuel fabrication plants and an increase in the impact at reprocessing plants. The net effect would be an overall decrease in the impact on the environment due to the characteristics of the reprocessing facilities and their sites.
- In the unlikely event there is a process incompatibility requiring additional processing at the fuel fabrication facility due to receiving plutonium as a solid, there could be a small incremental increase in the discharge of chemicals and radioactive materials into the nearby environs of plutonium fuel fabrication plants. This is not expected to produce a detectable impact.

3. Summary of Major Alternatives Considered

- No action
- Double containment of plutonium nitrate solution,
- Double containment of solid form,
- Single containment nonrespirable plutonium dioxide,
- Double containment nonrespirable plutonium dioxide.

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1. INTRODUCTION

The Atomic Energy Commission (AEC) regulations in 10 CFR Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Materials Under Certain Conditions" establishes, among other things, the requirements for preparation for shipment of certain material licensed by the AEC, including plutonium. The existing regulations permit the shipment of plutonium in any chemical or physical form, including liquid plutonium nitrate. Using the present criteria and requirements of Part 71, hundreds of packages containing plutonium nitrate solutions have been shipped with no reported instances of plutonium leakage from the containment vessel.

The present situation with respect to the quantity and specific activity (radioactivity per unit mass) of plutonium involved in transportation is expected to change significantly over the next several years. Increasingly larger quantities of plutonium will be recovered from power reactor fuel. Consequently, the quantities of plutonium shipped and the number of shipments made are expected to increase. For example, the amount of plutonium available for recovery was estimated to be about 500 kg in 1973 as compared to 20,000 kg in 1980. In addition, the specific activity of the plutonium will increase with higher reactor fuel burnup, resulting in higher gamma and neutron radiation levels, greater heat generation, and greater potential for pressure generation (through radiolysis) in shipping packages containing plutonium nitrate solutions.

Because of expected changes in the quantities and characteristics of plutonium to be transported and because of the inherent susceptibility of liquids to leakage, the Commission believes that safety would be enhanced if the physical form of plutonium for shipment was restricted to a solid, except for packages containing less than 20 curies. Accordingly, pursuant to the Atomic Energy Act of 1954, as amended, and section 553 of Title 5 of the United States Code, the Commission caused to have published in the Federal Register on August 1, 1973 (38 FR 20482), a notice that adoption of amendments to 10 CFR Part 71 were contemplated, and that all interested persons who desired to submit written comments or suggestions to the Commission should do so within sixty days. Appendix A contains a copy of the Federal Register notice of the proposed rule making. This document discusses the known and potential environmental impacts should the Commission adopt the subject amendments to Part 71 essentially as proposed.

2. PRESENT REGULATIONS

The AEC and the Department of Transportation (DOT) regulations[1] presently do not specify the form of plutonium for shipment. Rather, the standards set forth package performance requirements for normal conditions of transport and severe accidents and apply to all types of radioactive materials. International transport regulations published by the International Atomic Energy Agency and the regulations of many other countries are based on this same concept. Basically, the present regulations require that shipping containers for significant quantities of radioactive materials, such as plutonium, be designed to retain the material regardless of the form in which it is shipped and to assure that fissile material remains subcritical, under both normal and accident test conditions as specified in the regulations.* Each package design for shipping a millicurie or more of plutonium must be reviewed and approved by the AEC before it can be used. A container design is approved only after a thorough evaluation of the containment, structural, shielding, heat transfer and nuclear criticality safety characteristics of the container against the packaging standards in 10 CFR Part 71, taking into account the results of tests of prototypes of the container.

*The accident damage conditions are simulated by test conditions which include, in sequence, a 30-foot free drop on an unyielding surface; a puncture test involving a 40-inch drop of the package onto a 6-inch diameter steel rod; a 30-minute fire test at 1475° F; and immersion in water.

Plutonium is presently shipped as metal, as oxide powder, as mixed-oxide pellets in reactor fuel rods, as nitrate solution, and as solid low level waste (contaminated materials). Most of the shipments in the private sector, other than finished fuel rods and assemblies, have been made as nitrate solution because it is a convenient form resulting from reprocessing of fuel elements and is readily amenable to further processing. The shipping packages for the nitrate solution generally have a ten liter capacity containing up to 2.5 kilograms of plutonium The solution is contained in a polyethylene bottle inside a plastic bag inside a stainless steel pressure vessel inside the shipping container. The polyethylene bottle is vented to allow the gases evolved, directly or indirectly due to radiolysis, to separate from the solution and be released to the plastic bag. The pressure vessel contains a protected vent valve so that the receiver can safely release any pressure before opening the vessel.

3. PROPOSED REGULATIONS

Because of the expected changes in the characteristics of plutonium recovered from power reactors, the Commission has proposed a new section in 10 CFR Part 71 which would require (notwithstanding certain exemptions in Part 71) that plutonium in excess of 20 curies per package must be "shipped as a solid encapsulted to meet the requirements of special form as defined in § 71.4(o)(2) of this part (10 CFR Part 71), and shall be shipped inside an outer packaging which meets the requirements of this part for packaging of material in normal form." Appendix B contains the Part 71 definition of "special form". In addition, the proposed amendment to Part 71 states that the "authority provided in AEC licenses issued pursuant to this part (10 CFR Part 71) for the delivery to a carrier for transport of plutonium in a liquid form in quantities exceeding 20 curies per package, shall expire on (three years from the date of adoption of this amendment)."

4. DISCUSSION OF PROPOSED ACTION

The principal question resulting from the proposed amendment to the regulations is whether or not a particular physical form of plutonium should be specified for plutonium shipment. The following is a discussion of the rationale which has lead the Commission to propose the subject rule making and the effects of such an amendment should it be adopted.

4.1 Rationale for the Proposed Rule Making

Plutonium in any form presents a potential hazard to people and property. The degree of the hazard depends on conditions to which the plutonium is subjected and the controls exercised over the hazard. Packaging which meets the applicable regulations of AEC and DOT provides a high degree of assurance that there will be containment of the radioactive material during transportation.

Because of the expected changes in the characteristics of plutonium recovered from power reactors, the existing shipping packages for plutonium nitrate solutions (and possibly for solid form) will become obsolete. Economic factors will probably dictate considerably larger shipments (and larger packages) than currently used. There is little doubt that packages can be designed and built to meet regulatory standards established to protect the public health and safety during the transport of either aqueous

solutions or solid plutonium compounds. It should be clearly understood that the proposed rule is aimed at preventing leakage, as a result of human error in packaging, of plutonium during normal and accident conditions in transport.

The degree of risk associated with plutonium in transport depends, in part, on the form of the material. Differences in the likelihood of leakage of the three forms of plutonium which are presently being shipped (i.e., nitrate solution, oxide and metal) relate to a large extent, to their physical characteristics. Control by regulations of the potential for human error in packaging radioactive solutions has practical limits. AEC license-exempt contractors have been shippers of radioactive materials for nearly twenty-five years. Based on records of experience which have been accumulated since 1949, one particular factor has been identified in cases involving the release of radioactivity - shipment of material in liquid form. In about 50% of the cases where material escaped from a container, the cause was the leakage of liquid.[2,3] It should be emphasized, however, that the large majority of the incidents during shipment of radioactive materials involved very small quantities of radioactive materials. No packages approximating the kind for shipping large quantities (greater than 20 curies) of plutonium have ever experienced leakage during transportation. Nonetheless, the above record serves to support

the acceptance of the premise that shipment of a liquid poses a greater risk of release of radioactivity than the shipment of a solid. This point becomes more important when the container of a liquid is internally pressurized, as occurs with plutonium nitrate solutions.

It is known that plutonium nitrate solutions generate gases which will pressurize sealed containers.[4,5] The Staff estimates that, because of the changing characteristics of plutonium with higher fuel burn-ups, the off-gassing rate of plutonium nitrate solutions will increase by a factor of three or four within the next decade. The principal gases evolved are oxygen and hydrogen with a small quantity of nitrogen. Ignition or detonation of the hydrogen/oxygen gas mixtures by a concentrated heat source, by a shock wave (e.g., a pressure jump caused by rapid venting or a shock induced by impact) or by spark (e.g., static electricity during venting) has a very low probability of occurrence.

One exploratory experiment to determine the feasibility of catalytically recombining the hydrogen and oxygen gases evolved from the nitrate solutions resulted in only limited success in that the palladium catalyst was poisoned after exposure to the gases (presumably because of the presence of nitric acid in the plutonium nitrate solution) for approximately seven

days.[4] A program was undertaken to develop a vent and seal which would relieve the evolved gases but contain concentrated nitric acid solutions of plutonium during normal transportation.[6] In the report on that program, it was noted that careful observation of the recommended vent assembly should be made while in use to detect adverse effects of exposure of the vent to the plutonium nitrate solution. It was noted also that care must be used in installation of the seal to be certain that it does not fall out of the cap before tightening. Therefore, more packaging activities may be required to assure safety in liquid packaging.

Just as in any situation involving the packaging of radioactive materials, a high level of human performance is necessary on a continuing basis to assure against leakage caused by human error in packaging. As the number of plutonium shipments increases, and packages become larger and more complex in design, the likelihood of such human error increases. The likelihood of human error with the packaging for liquid, anticipated to be more complex in design as indicated above, is probably greater than with the packaging for solid. Furthermore, should a human error occur in packaging preparation or closure, the likelihood of liquid escaping from an improperly prepared package is considered greater than for most solids and particularly for those solid plutonium materials expected to be shipped. As mentioned above, this point becomes more important when the packaged

liquid is internally pressurized as will be inherently so for the plutonium nitrate solution.

The arguments for requiring a solid form of plutonium for shipment must be largely judgmental, in that there is no firm evidence on which to base statistical probabilities or to assess quantitatively the incremental increase in safety which is expected. Therefore, the above discussion is not intended to be a technical argument which incontrovertibly leads to the conclusion. It is, rather, a presentation of the rationale which has lead the Staff to its conclusion that a possible problem may develop and that the proposed action is a step towards increased assurance against the problem developing. In fact, the National Transportation Safety Board has recommended approaches such as the subject rule making to enhance the safety of the transportation of hazardous materials. In a special study on the risk concepts in dangerous goods transportation, the Board wrote in its conclusion:[7]

> "Movement of dangerous goods in transportation systems creates certain risks. Approaches upon which present regulations are based have resulted in apparent inequities and serious difficulties under these regulations, as described herein. Performance standards, while helpful, will not resolve these difficulties. Therefore, the Board concludes that a new basis is required for these regulations."

The conclusion continued:

> "The Board believes that risk-based concepts can provide a responsive logical framework for development of the

objectives, approaches, and analytical methods required to overcome the difficulties with existing regulations, and to improve these dangerous goods transportation regulations and safety."

The Staff believes the likelihood of plutonium leakage as a result of human error during preshipment operations would be substantially reduced and safety would be enhanced if the form of plutonium for shipment was limited to a solid, since solids are less susceptible to leakage. The proposed action would result in the requirement that plutonium (in quantities greater than 20 curies) be shipped in a solid form and that the shipping package provide at least double containment of the contents.

4.2 Possible Effluents Generated as a Result of the Proposed Rule Making

Plutonium occurs in nature in only the merest traces. It is produced principally by exposure of uranium-238 to neutrons in a nuclear reactor. In the reprocessing of spent fuel elements, the plutonium is generally obtained as a solution of the nitrate in nitric acid. Under existing circumstances, the recovered plutonium is placed in storage for future use or is shipped to fuel fabrication plants for conversion to the oxide form (a solid) and subsequent processing into reactor fuel. For purposes of this analysis, the baseline situation (i.e., the situation under the present shipping regulations) is that the fabrication facility

receives plutonium nitrate solution and that the nitrate is converted to the oxide at the fabrication plant. The oxide is then converted into reactor fuel elements. Table 1 lists the effluents and solid waste which are estimated to be generated at fuel reprocessing plants and fuel fabrication plants under the baseline situation (the subject rates are in the column "Reference or Present Situation").

The basis for the rates given in Table 1 for the baseline or presen situation is the Barnwell Nuclear Fuel Plant[8] and the Westinghouse Recycle Fuels Plant.[9] These two facilities are examples of modern plants and represent the size of plants for the future. It should be noted that the latter facility has been designed to receive plutonium dioxide rather than the nitrate solution and that the oxide will be processed into fuel pellets without the additional step of reconstituting the nitrate. Therefore, it was necessary to estimate the emissions and waste associated with the conversion of the nitrate to oxide at the fuel fabrication plant.

Plutonium dioxide is most often prepared from the nitrate through precipitation of a precursor such as oxalate, peroxide or hydroxide.[10,11] Direct thermal denitration has been investigated but is not widely utilized.[12] Each conversion method individually offers specific advantages and disadvantages from the view points of material handling requirements, cost of unit operations, process yields, and end product quality. However, there appears to be no inherent overall advantage from an environmental viewpoint for one

TABLE 1

ESTIMATED EFFLUENTS AND WASTE GENERATED AT REPROCESSING AND FABRICATION PLANTS*

	REFERENCE OR PRESENT SITUATION (gm/sec)[a]	LIKELY SITUATION[h] UNDER PROPOSED RULE MAKING (gm/sec)[a]	INCREMENTAL[e] CHANGE (%)	UNLIKELY SITUATION[f] UNDER PROPOSED RULE MAKING (gm/sec)[a]	INCREMENTAL[e] CHANGE (%)
REPROCESSING PLANT[b]					
Gaseous Effluents					
Oxygen	nil	0.16	(See Note f)	0.16	(See Note f)
Carbon Monoxide	1.1	1.2	10.0	1.2	10.0
Carbon Dioxide	nil	0.31	(See Note f)	0.31	(See Note f)
Oxides of Nitrogen	22.0	~22.0	0.2	~22.0	0.2
Oxides of Sulfur	8.3	8.3	0.0	8.3	0.0
Water Vapor	5300.0	~5300.0	0.0	5300.0	0.0
Plutonium	5.6×10^{-3} μCi/sec	~5.6×10^{-3} μCi/sec*	5.9×10^{-4}	~5.6×10^{-3}	5.9×10^{-4}
Solid Waste	~100-300 ft^3/day	~150-350 ft^3/day	20 - 50	~150-350 ft^3/day	20 - 50
FABRICATION PLANT[c]	(See Note d)				
Gaseous Effluents					
Oxygen	0.08	0.0	(See Note g)	0.083	(See Note f)
Nitrogen	0.0	0.0	(See Note g)	0.004	(See Note f)
Carbon Monoxide	0.07	0.0	(See Note g)	0.07	0.0
Carbon Dioxide	0.15	0.0	(See Note g)	0.15	0.0
Oxides of Nitrogen	0.021	nil	(See Note g)	0.021	0.0
Water Vapor	0.34	0.0	(See Note g)	0.34	0.0
Plutonium	1.4×10^{-5} μCi/sec	~1.4×10^{-5} μCi/sec	~(-0.1)	~1.4×10^{-5} μCi/sec	~0.1
Solid Waste	56 ft^3/day	33 ft^3/day	-41.0	59 ft^3/day	6.0

Note: *Footnotes are on the following page.

FOOTNOTES TO TABLE 1

a. Except where noted. The emission rates have been averaged over a full days operation at the capacities given in note c.

b. Effluents such as tritium and krypton have been omitted from this table since such emissions are not affected by the proposed rule making.

c. It is assumed that fuel fabrication plants for recycle fuels will be designed for a capacity of approximately 25 kg Pu/day[9] while reprocessing plants will be designed for producing approximately 50 kg Pu/day.[13] Therefore, there would be two recycle fuel fabrication plants for each fuel reprocessing plant.

d. It is assumed, for purposes of this analysis, that the baseline situation is the fabrication facility receiving plutonium nitrate solution and converting the nitrate to the oxide according to process operations given in Appendix C. The estimated effluents from these processes have been added to the estimated effluents[9] of the subsequent operations to produce the mixed oxide fuels.

e. Incremental change is the change from the baseline or present situation to the subject situation under the proposed rule making.

f. Inconsequential increase.

g. The gaseous emission rates in the reference or present situation are essentially inconsequential when compared with either the normal atmosphere composition of the particular chemical or the emissions from one automobile.

h. The likely situation is defined, for purposes of this analysis, as the reprocessor preparing plutonium dioxide which is directly usable by the fuel fabricator without the necessity of redissolving the oxide at the latter plant.

i. The unlikely situation is defined, for purposes of this analysis, as the reprocessor preparing plutonium dioxide and, because of process incompatibility or some other reason, the fuel fabricator redissolves the oxide to form the nitrate solution.

processing technique over the others. The oxalate precusor method is a well-developed technique for converting plutonium nitrate to oxide and is the process planned for the Plutonium Product Facilities of the Barnwell Nuclear Fuel Plant.[13] Therefore, the basis for the estimates in Table 1 of the effluents and waste generated in the baseline situation as a result of the nitrate to oxide conversion is that of the oxalate as a precursor. Appendix C contains a discussion of the process steps in the oxalate precursor method of producing plutonium dioxide.

Under the proposed amendment, plutonium would be converted to a solid form, most likely the oxide, at the reprocessing facility and shipped to the various fuel fabrication plants for subsequent use. In fact, the Staff believes that basic economic considerations (which will be discussed below) will tend to drive the industry in the direction of converting the nitrate to the oxide at the reprocessing plant independent of the proposed rule making.

Since plutonium dioxide which is directly usable for fabricating commercial light water reactor fuels and liquid metal fast breeder reactor fuels can be produced at the reprocessing plant, additional processing to redissolve the oxide would not likely be necessary at the fuel fabrication plant. Thus, there would be a decrease in the effluents and waste generated at fuel fabrication plants

as a result of the centralized conversion of plutonium nitrate to plutonium dioxide at reprocessing facilities and there would be an increase in the effluents and waste generated at the reprocessing plants. Because of the characteristics of the fuel reprocessing facility and site (e.g., large scale of operation, higher exhaust stack, greater exclusion area and higher volumetric air flow within the facility) compared to the fuel fabrication plant and site, the net effect of centralizing nitrate conversion at the reprocessing plant would be an overall decrease in the impact from that operation.

Table 1 shows that, in the likely situation (defined for purposes of this analysis as the reprocessor preparing plutonium dioxide which is directly usable at the fuel fabrication facility without the necessity of redissolving the oxide at the latter plant), the incremental change in emission rates of gaseous effluents would be very small in all cases. It should be noted that the normal atmosphere is approximately 21% oxygen and approximately 0.04% carbon dioxide so that those respective emissions from the facilities are inconsequential. The estimated increase in the emission rate of carbon monoxide (0.1 gm/sec) at the reprocessing plant is a factor of approximately two lower than the emission rate of CO from one automobile traveling 25 miles per hour (based on an emission factor of 35 gm CO/mile).[14] The increase in the

in the emission rate of plutonium at the reprocessing plant would be essentially undetectable (a 5.9×10^{-4} percent increase). The gaseous emission rates in the baseline situation for the fuel fabrication plant are essentially inconsequential when compared with either the normal atmosphere composition of the particular chemical or the emissions from one automobile. Table 1 shows that most of the nonradioactive emissions from the fuel fabrication plant would be eliminated under the proposed rule making. The emission rate of plutonium at the fuel fabrication plant would be decreased.

The solid waste generated at the fuel fabrication facility as a result of the conversion of nitrate to oxide would be generated at the reprocessing plant under the proposed rule making. There would be no net change in the volume of waste generated if there is no economy of scale at the reprocessing plant (this is a conservative assumption).

In the unlikely situation in which the fuel fabricator desires to redissolve the plutonium dioxide to form the nitrate prior to further processing, the proposed amendment would cause the conversion of the nitrate to the oxide at both the reprocessing plant and the fuel fabrication plant as well as the reconstitution of the nitrate at the fuel fabrication plant. Table 1 also lists

the effluents and waste generated at each facility in this situation (in the column "Unlikely Situation Under Proposed Rule Making"). Appendix D contains a discussion of the postulated process steps in converting the oxide to the nitrate. Table 1 shows that, as in the situation above, the incremental change in the gaseous effluents is small and/or inconsequential in all cases.

The solid waste generated at the reprocessing plant would be the same as in the likely situation. There could be a 6 percent increase in the waste generated at the fuel fabrication plant, in comparison with the baseline situation.

In the unlikely situation postulated above, the Staff took into account the possible need to redissolve the oxide for the purpose of removing accumulated Am-241, a decay product of Pu-241. Generally speaking, we do not believe it will be necessary to remove the americium at the fuel fabrication plant prior to further processing. For a further discussion of this, see Appendix E.

4.3 Additional Considersions on the Plutonium Shipping Form

With respect to the health and safety benefits, the arguments for requiring a solid form of plutonium for shipment are largely judgmental, in that there is no firm evidence on which to base statistical probabilities or to assess quantitatively the incremental increase in safety which is expected. As noted previously,

the proposed rule is aimed at preventing leakage, as a result of human error in packaging, of plutonium during both normal and accident conditions in transport. It is the Staff's judgment that the proposed rule would significantly enhance the degree of safety in shipping plutonium since the proposed amendment would obviate the difficulty of containing liquids under pressure. Moreover, the proposed rule would in the Staff's opinion, decrease the dependence on the human element for high performance in preparing packages for shipment and would decrease the possibility of leakage during transport due to human error.

An appropriate time for implementation of a requirement for shipping solid forms of plutonium is based on two considerations: a) the time when increased plutonium recycle use may become a reality and b) the time required for industry to implement the plant changes necessary to accommodate the new requirement. The Staff judges that the shortest time frame in which the proposed rule would become effective is three years, based on our estimates on the reality of recycle and time required for implementation of the amendment. However, as previously mentioned, a somewhat longer period of time such as four years would, in the Staff's opinion, still meet the objective of the proposed rule making.

The need for the shipment of small quantities of plutonium as the nitrate solution is recognized. It is expected that this would consist primarily of items such as analytical samples. To accommodate this need, the proposed amendment stipulates that

quantities not exceeding 20 curies be exempted from any requirement for solid form shipment. The value of 20 curies represents a "large quantity" of plutonium as defined in the AEC's transportation regulations, 10 CFR Part 71. Thus, the existing regulations covering the shipment of less than 20 curies of plutonium would remain in effect. That quantity of plutonium represents about 320 grams of plutonium-239 or about 2 grams of high burn-up plutonium with its higher specific activity. It is also recognized that there may be unusual cases where the shipment of small quantities of plutonium nitrate in excess of 20 curies would be warranted. Under the provisions of Part 71, specific exemptions can be granted if the Commission determines for the particular case there is adequate assurance of health and safety.

As previously mentioned, the likely situation resulting from the adoption of the proposed rule making was, for purposes of the above analysis, the reprocessor preparing plutonium dioxide which is directly usable by the fuel fabricator without the necessity of redissolving the oxide at the fabrication plant. The unlikely situation was considered to be the reprocessor preparing a plutonium dioxide from the nitrate solution and the fuel fabricator redissolving the oxide to reconstitute the nitrate solution. It should be noted that there are research and development studies underway to develop a solid form of plutonium which is more amenable to

dissolution than the oxide, such as plutonium nitrate crystals. It is the Staff's opinion that, should such a solid form become viable from the environmental, safety and economic viewpoints, this situation would result in less of an impact than the reconstitution of the nitrate solution from the oxide and would not alter the basic arguments for adoption of the proposed rule making.

With respect to employee radiation doses possibly resulting from the proposed rule making, fuel cycle facilities for handling plutonium will, of necessity, be designed to control both gamma ray and neutron exposures associated with plant activities. The AEC requires that each applicant desiring to carry out activities involving licensed material (such as plutonium) provide the AEC, among other things, a complete description of the applicant's proposed plant design features and other control measures for maintaining radiation exposure as low as practicable. Before authorizing activities involving plutonium at a fuel cycle facility, the Staff must, among other things, make a favorable determination with respect to the applicant's radiation control for maintaining occupational exposures within the limits of 10 CFR 20. Radiation dose limits of 10 CFR 20 are based on a thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of plant personnel within these limits ensures that the risk associated with radiation exposure is no greater than those risks normally accepted by workers in other

present day industries. The total dose from the operations which could be affected by the proposed rule making would be influenced by several factors for which definitive numerical values are not available. However, an applicant's implementation of the regulations and the various regulatory guides regarding reducing exposures and maintaining occupational exposures as low as practicable is expected to result in an aggregate dose significantly below the dose limits in 10 CFR 20. Under the likely situation (as defined above) resulting from the proposed rule making, total employee dose is not expected to increase and could possibly decrease, primarily because there would be fewer packages handled. Under the unlikely situation, it is possible that there could be an increase in the aggregate employee dose but, as indicated above, this should not result in a significant effect. Upon consideration of the foregoing, we believe the matter of employee exposures in connection with the proposed rule making is not a significant factor in view of the enhanced safety in the shipping of plutonium as a result of the proposed rule making.

A requirement to ship plutonium in a solid form would eliminate the necessity to convert the nitrate to the oxide in the primary production sequence of the fuel fabricator. Any equipment now in place for such operations would not have to be discarded since the equipment could be used for scrap recovery operations.

4.4 Possible Cost Penalties/Advantages as a Result of the Proposed Rule Making

In order to determine whether the proposed rule making would result in an overriding economic burden on the industry, comparative cost estimates were made by the Staff for processing plutonium under three different circumstances related to the consideration of the plutonium shipping form. The three circumstances were (a) conversion of plutonium nitrate to plutonium dioxide by the reprocessor, (b) preparation of plutonium nitrate solution from plutonium dioxide by the fuel fabricator, and (c) conversion of plutonium nitrate to plutonium dioxide by the fuel fabricator. The Staff's cost estimates were based on AEC information and do not necessarily reflect present costs at individual facilities nor do they reflect industry charges. We believe the significant aspect to consider is the relative costs involved. Importantly, even if there were a significant change in the estimates, it is not likely that the results would be an overriding factor in the decision to adopt the proposed rule, recognizing their small contribution to the total fuel costs, as indicated below. Additional details on the cost estimates are contained in Appendices C and D.

In the unlikely situation where the plutonium dioxide must be redissolved to nitrate by the fuel fabricator because of process incompatibility, a cost penalty of about $320/kilogram would result. To put this $320/kilogram cost penalty into perspective, this would represent an increase in the fuel cycle cost for an LWR by about 2%, resulting in an increase in generating costs of about 0.5% which would increase the consumer's cost by about 0.2%. This cost is made up of two components, $130/kilogram for conversion of nitrate to oxide at the reprocessing plant and $190/kilogram for preparation of nitrate at the fuel fabrication plant. For this postulated case, the $320/kilogram would represent approximately 10% of the present fuel fabrication costs for liquid metal fast breeder reactor (LMFBR) type fuel (a ratio which would be expected to increase by perhaps a factor of 2 as the cost of LMFBR fabrication is lowered). As mentioned above, this cost would result in an insignificant increase in the overall fuel cycle cost.

If, as expected, the plutonium dioxide produced at the reprocessing plant is used directly by the fuel fabricator, there would be an economic advantage of about $170/kilogram. This cost advantage results primarily from the reprocessor's larger scale of operation and cheaper handling of liquid wastes. In addition, it appears evident that the cost of storage of oxide would be significantly

lower than the cost of storage of the nitrate solution, principally because of the greater density of the oxide. Thus, basic economic considerations will tend to drive the industry in the direction of converting the nitrate to the oxide at the reprocessing plant, independent of the proposed rule making.

Packaging costs are expected to be less for the oxide form than for similar quantities of plutonium nitrate solution because of simpler package design. Present packaging and transportation costs are estimated to be about $50/kilogram less for plutonium metal or oxide than for nitrate solutions. Larger capacity packages designed to accommodate changing characteristics of plutonium would no doubt increase the cost differential between nitrate solution and oxide shipping. Thus, economics would favor, to an even greater extent, the shipping of solid versus liquid form. In addition, the requirements for the physical protection of plutonium in transit, regardless of form, will likely establish the overriding costs of transportation and will place a high premium on getting as much plutonium as possible on a vehicle, a situation which would most likely favor the oxide form because of its higher packaged density.

5. ALTERNATIVES TO THE PROPOSED ACTION

The proposed action concerns an amendment of the AEC regulations to require that plutonium (in excess of 20 curies per package) be shipped as a solid encapsulated to meet the requirements of special form. The basic alternatives to the proposed action are: 1) no-action; 2) permit the continued shipment of any physical form of plutonium but revise the package performance standards of Part 71 to require double containment of liquid contents; 3) require that plutonium be shipped as a solid and with double containment of the contents, exempting certain materials from the double containment requirement; 4) require that plutonium be shipped as a nonrespirable solid in packages which meet Part 71 requirements for material in normal form; and 5) require that plutonium be shipped as a nonrespirable solid in double containment packages.

The alternatives described above will be discussed in terms of four parameters which should show the relative costs/benefits for each alternative. The parameters are process costs, packaging costs, shipping costs, and health and safety benefits. Cost estimates have been derived for those cases in which process changes are required in order to accommodate the alternative. Such cost estimates take into account the matter of process compatibility between the producer and user of the material. The packaging and transportation costs and

health and safety benefits associated with the alternatives are dealt with qualitatively based on Staff judgment because available information does not permit quantitative assessment.

5.1 No-Action (Alternative 1)

Under this alternative, the option would be left open as to what form of plutonium should be shipped. Since the industry is currently set up to ship and receive plutonium in the nitrate form, there would be no changes required in the process methods. Plutonium would continue to be produced at the reprocessing plant as the nitrate solution and shipped in that form to the fuel fabricator for conversion to oxide and subsequent fabrication. Thus, process effluents, waste, and costs would not change.

It is expected that future costs for packaging and shipping plutonium as a nitrate solution will increase because the increase in specific activity and quantities of plutonium to be shipped will make the present nitrate packages obsolete. The increased costs will principally be associated with design, fabrication, testing, and maintenance of the packages and with obtaining the necessary Regulatory approval. It is expected that the degree of safety associated with this alternative would decrease to some extent because of the increased number of packages and shipments coupled with the relatively high degree of dependence on the human element to prepare and maintain packages so as to preclude leakage of liquid contents under pressure.

5.2 Permit All Physical Forms to be Shipped but with Double Containment for Liquids (Alternative 2)

The discussion of alternative 1 is applicable to this alternative, except that packaging costs would be somewhat greater because of the additional degree of containment required. The health and safety aspects would be improved since leakage due to a single packaging error would be controlled. However, there would still exist a relatively high dependence on the proper preparation of the packages to preclude leakage of the liquid.

5.3 Solid Form with Double Containment (Alternative 3)

This alternative meets, in the Staff's opinion, the basic intent of the proposed rule making in that the health and safety considerations discussed in Section 4, as they relate the advantages of a solid form over liquid, are applicable. The requirement of double containment of the contents provides added assurance against leakage in the event of packaging errors.

The only difference between this alternative and the proposed rule is that this alternative would not require that the inner containment have the special characteristics of the "special form" encapsulation (ability to withstand conditions of dropping, heating, percussion, and immersion specified in Part 71 and in Appendix B). A more general requirement of double containment, with the inner container maintaining leak tightness within a

Part 71 package subjected to normal and accident test conditions, would still meet the basic intent of specifying two barriers. The improved health and safety aspects would still be maintained as discussed in Section 4. The effectiveness of using double containment in lieu of requiring a nonrespirable form would also be maintained. Certain forms of plutonium that are essentially nonrespirable, such as plutonium contained in reactor fuel elements, metal, metal alloys, and other solid materials as may be appropriate, could be exempted from this requirement without any sacrifice in health and safety protection. While the proposed rule states that the shipping package must meet special form requirements, the Staff considers alternative 3 an acceptable alternative.

5.4 Nonrespirable Solid in Packages Meeting Part 71 Requirements (Alternative 4)

With respect to the health and safety considerations as discussed in Section 4, the advantages of a solid form over liquid are also applicable to this alternative. In addition, although the Staff believes that the likelihood of leakage of solids is extremely low, a nonrespirable form was considered because it would provide greater protection against acute human exposure in the event of leakage of the plutonium from the package.

Little is known, however, about a form of plutonium which would satisfy the nonrespirability characteristic except that the particle size would have to be greater than ten microns. Possible forms which can be identified, such as high-fired ceramic spheres or pellets that are large enough to avoid the problem of inhalation and dispersion and strong enough to remain in a nonrespirable form under transport conditions, are considered to be incompatible with current fuel fabrication technology and could require either major pretreatment by the fabricator before utilization or development and in-reactor qualification of new fuel concepts. The type and extent of pretreatment is difficult to predict at this time. Even if such a form could be readily defined and produced, the process costs would be expected to be significantly higher than estimated for the hypothetical situation given in Section 4, including both the cost of producing the nondispersible form at the reprocessing plant and converting it to a usable form at the fabrication plant. Thus, it is the Staff's conclusion that the technology is not available and, even if it were, the effluent impacts associated with the processes and the additional costs would have to be balanced against the incremental gain in safety resulting from this form. In view of the uncertainties associated with the development of the needed technology for this alternative, the Staff believes that the requirement of solid form with packages

providing double containment (alternative 3) is the more viable alternative.

5.5 Nonrespirable Solid in Double Containment Packages (Alternative 5)

The considerations for this alternative are the same as those discussed under alternative 4, except that the health and safety benefits as well as the cost would be somewhat increased by the double containment of the material. Also, as stated under alternative 4, the lack of suitable technology for this form renders this alternative nonviable.

6. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

6.1 Adverse Effects Which Cannot be Avoided

A requirement to ship plutonium in a solid form only would result in the operations involved in the conversion of the nitrate to the oxide being centralized at the reprocessing plant, unless the fuel fabrication plant were located on the same site. Plutonium dioxide, which could be directly usable in fuel fabrication processes for producing commercial light water reactor fuels and LMFBR fuels, can be produced at the reprocessing plant without the necessity of converting the plutonium back to the nitrate form at the fuel fabrication facility. A potentially adverse effect could occur if, because of process incompatibility or some other reason the fuel fabricator cannot use the oxide directly and must perform additional processing (e.g., remake the oxide). This is expected to be an unlikely and limited situation. As indicated above, there could be some increase in effluents and additional losses of plutonium in waste streams at the fuel fabrication plant but these have been estimated and shown to be insignificant in terms of the overall fabricator's activities.

6.2 Relationship Between Short-Term Uses of the Environment and Enhancement of Long-Term Productivity

Based on the information contained in this statement, it appears to the Staff that the proposed action does not involve tradeoffs

between short-term environmental gains at the expense of long-term losses, or vice versa.

6.3 Irreversible and Irretrievable Commitments of Resources

Based on the considerations contained in Section 6.1, it appears to the Staff that the proposed action would neither irreversibly curtail the range of potential uses of the environment nor irretrievably commit resources.

7. COST-BENEFIT ANALYSIS

The costs and benefits of the proposed rule making are measured from the base conditions of the regulations and the environment as presently existing. A cost is considered a potentially detrimental effect produced by the proposed action upon the quality of air, water or other factors of the environment that have negative social or economic aspects. A benefit, in the context of the proposed action, is considered an effect produced by the proposed action that improves the quality of the environment or enhances the safety of shipping plutonium. Table 2 summarizes the cost-benefit comparison of the alternatives with respect to the reference or present situation (the no -action case) defined as the shipment of plutonium nitrate solution in packages meeting Part 71 requirements. Based on the overall balance of the information contained in Table 2, the Staff concludes that from the environmental viewpoint, the benefits of the proposed action outweigh the costs.

TABLE 2

Cost-Benefit Comparison for Alternatives[a]

	Proposed Action	Double Containment Plutonium Nitrate Solution	Double Containment Solid Form	Single Containment Nonrespirable Plutonium Dioxide	Double Containment Nonrespirable Plutonium Dioxide
Economic[b]					
Processing Costs	-$170/Kg Pu[e] (-0.1% of the cost of electric power to the consumer from LWR's)	Same as Reference (i.e., shipping liquid plutonium nitrate in single containment)	-$170/Kg Pu[e] (-0.1% of the cost of electric power to the consumer from LWR's)	+$320/Kg[f] or more (+0.2% of the cost of electric power to the consumer from LWR's)	+$320/Kg Pu[f] or more
Shipping Costs[c]	-$50/Kg Pu (-0.03% of the cost of electric power to the consumer from LWR's)	Higher than Reference	-$50/Kg Pu (-0 03% of the cost of electric power to the consumer from LWR's)	-$50/Kg Pu or more	-$50/Kg Pu or less
Environmental					
General Public Exposure					
Normal Operation	Same as Reference	Same as Reference	Same as Reference	Same as Reference	Same as Reference
Abnormal Operation[d]	Lower Risk than Reference	Somewhat Lower Risk than Reference	Lower Risk than Reference	Lower Risk than Reference	Lower Risk than Reference
Air Quality	Potential for Insignificant Increase in Gaseous Effluents Compared to Reference Case	Same as Reference	Potential for Insignificant Increase in Gaseous Effluents Compared to Reference Case	Potential for Insignificant Increase in Gaseous Effluents Compared to Reference Case	Potential for Insignificant Increase in Gaseous Effluents Compared to Reference Case

Note: Footnotes are on the following page.

FOOTNOTES TO TABLE 2

a. With respect to reference or present situation, defined as the shipment of plutonium nitrate solution in packages meeting Part 71 requirements.

b. Economic costs are aggregate costs to the entire industry.

c. Shipping costs do not include unknown costs of physical protection for safeguards purposes.

d. The most likely abnormal operations consist of small leaks resulting from human error. The risk of public exposure from high consequence, low probability accidents is assumed to be negligible in comparison with more likely, small leaks of material.

e. This estimate is for the likely case that the plutonium oxide is directly usable at the head end of the fabrication process. In the unlikely case that the plutonium must be converted to nitrate, a cost of +$320/Kg is incurred.

f. This estimate assumes the cost of both preparation and pretreatment for use of the nonrespirable form will be higher than the unlikely case in footnote e.

8. References

1. Department of Transportation Regulations Title 49 Code of Federal Regulations, Parts 170-179.

2. Patterson, D. E., "The Accident Experience of the USAEC in the Shipment of Radioactive Material," In: Proceedings of the Second International Symposium on Packaging and Transportation of Radioactive Materials, October 14-18, 1968, pp. 199-209.

3. McCluggage, W. C., "The AEC Accident Record and Recent Changes in AEC Manual Chapter 0529," In: Proceedings of the Third International Symposium on Packaging and Transportation of Radioactive Materials, August 16-20, 1971, and USAEC Report No. BNWL-SA-3906 (1971).pp. 108-129.

4. Sheppard, J. C., "Alpha Radiolysis of Plutonium (IV) - Nitric Acid Solutions," USAEC Report No. BNWL-751, May 1968.

5. Crawley, D. T., "Pressure Build-up of Plutonium Nitrate Solutions in Sealed Shipping Containers," USAEC Report No. ARH-1093, July 15, 1969.

6. Lee, H. A., "Vent and Seal for Polyethylene Bottles Used with Plutonium Nitrate Shipping Containers," USAEC Report No. ARH-645, June 18, 1968.

7. National Transportation Safety Board, "Risk Concepts in Dangerous Goods Transportation Regulations," Report No. NTSB-STS-71-1, January 27, 1971.

8. Final Environmental Statement Related to the Construction and Operation of Barnwell Nuclear Fuel Plant (Docket No. 50-332), U.S. Atomic Energy Commission, Directorate of Licensing, Fuels and Materials, January, 1974.

9. Westinghouse Electric Corporation, "Recycle Fuels Plant Environmental Report" Docket No. 70-1432, July 1973.

10. Brite, D. W., "Plutonium Fuel Technology Part 1: Plutonium Fuel Fabrication," Nuclear Technology 18: 87-96, May 1973.

11. Thomas, I. D., "Plutonium Ceramic Fuel Fabrication," In: Plutonium Handbook - A Guide to the Technology, (Ed. O. J. Wick), Gordon and Breach, Science Publishers, New York (1967), pp. 619-642.

12. Ibid, p. 622.

13. Allied-Gulf Nuclear Services, Barnwell Nuclear Fuel Plant, Preliminary Safety Analysis Report, Addendum No. 7, Plutonium Product Facilities, Docket 50-332, July 2, 1973.

14. "Compilation of Air Pollutant Emission Factors," U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, North Carolina, Revised Edition, February, 1972, p. 3-2.

Appendix A

Federal Register Notice of Proposed Rule Making

consolidated basis, in the registrant's annual report to stockholders, the financial statements required for such subsidiaries and 50 percent or less owned persons by the form otherwise appropriate for an annual report by the registrant to the Securities and Exchange Commission in lieu of Form 12-K [17 CFR 249.312].

Notwithstanding the foregoing, annual reports and financial statements of subsidiaries and 50 percent or less owned persons may be omitted, if in the aggregate (i) neither the registrant's and its subsidiaries' investments in and advances to, nor their proportionate share of the total assets (after intercompany elimination) of, such subsidiaries and other persons do not exceed 10 percent of the total consolidated assets, exclusive of such investments and advances, at the date of the most recent annual financial statements being filed; (ii) the total sales and revenues (after intercompany eliminations) of such subsidiaries or other persons, reduced to the percentages of equity interests held by the registrant and its subsidiaries in such subsidiaries and other persons, do not exceed 10 percent of the consolidated sales and revenues for the most recent fiscal year for which income statements are being filed; and (iii) the registrant's and its other subsidiaries' equity in the income before income taxes and extraordinary items of the subsidiaries and other persons does not exceed 10 percent of such income of the registrant and consolidated subsidiaries, exclusive of such equity in the subsidiaries and other persons, for the most recent fiscal year for which income statements are being filed, provided that, if such income of the registrant and its consolidated subsidiaries for the last fiscal year is at least 10 percent lower than the average of such income for the last five fiscal years, such average income may be substituted in the determination.

5. If the registrant files annual reports with the Interstate Commerce Commission or the Federal Communications Commission, the following reports and statements shall be filed:

(a), (b) and (c) (No change)

(d) For each majority-owned subsidiary and 50 percent or less owned person accounted for by the equity method of the registrant which does not file reports with the Federal Communications Commission or the Interstate Commerce Commission and whose financial statements are not included on either an individual or consolidated basis in the annual reports filed pursuant to clause (a), (b) or (c) above, the financial statements (which need not be audited) required for such subsidiaries and 50 percent or less owned persons by the form otherwise appropriate for an annual report by the registrant to the Securities and Exchange Commission in lieu of Form 12-K [17 CFR 249.312].

Notwithstanding the foregoing, annual reports and financial statements of subsidiaries and 50 percent or less owned persons may be omitted pursuant to the criteria for omission specified in Instruction 4.

6. (No change)

7. A statement shall be filed describing any change in accounting principles or practices followed by the registrant, or any change in the method of applying any such accounting principles or practices which materially affected the financial statements being filed with the Commission pursuant to Instruction 4 or 5 for the fiscal year covered by the report or will materially affect the financial statement of future fiscal years, and which had not been previously reported. State the date of the change and the reasons therefor. A letter from the registrant's independent accountants approving or otherwise commenting on the change, shall be filed as a part of the exhibit.

PART 259—FORMS PRESCRIBED UNDER THE PUBLIC UTILITY HOLDING ACT OF 1935

§ 259.5s [Amended]

XIII. Section 259.5s (Form U5S). The INSTRUCTIONS AS TO FINANCIAL STATEMENTS would be amended to read as follows:

INSTRUCTIONS AS TO FINANCIAL STATEMENTS

1. *Consolidating statements.* (a) There shall be filed for each registered holding company in the system a consolidating balance sheet as of the end of the calendar year and consolidating statements of income, source and applications of funds, and retained earnings and other stockholders' equity for the calendar year. These consolidating statements shall set forth the individual statements of the parent company and each subsidiary included in the consolidation as well as the elimination adjustments and the consolidated statements. Where any holding company system includes more than one registered holding company, separate consolidating statements shall be filed for each subsidiary registered holding company and its subsidiaries; and, if such subsidiary holding company is included in consolidation with its parent, the consolidated statements of such subsidiary holding company shall be shown in the consolidating statements of the top registered holding company.

(b) Consolidating statements shall be prepared in accordance with the requirements of Regulation S-X [17 CFR Part 210] which governs the examination and the form and content and the basis of consolidation of the financial statements, and prescribes the statements of retained earnings and other stockholders' equity and the schedules to be filed. The individual corporate and consolidated statements, included in the consolidating statements, of the top registered holding company and of each other system company filing this report pursuant to section 13 or 15(d) of the Securities Exchange Act of 1934 shall be audited in accordance with Regulation S-X [17 CFR Part 210]. Separate notes supporting individual statements of a system company may be omitted if the required information is separately set forth in the notes supporting the consolidated statements of its parents. Such notes may also be omitted, except in the case of a system company filing this report pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934, if all companies for which notes are omitted pursuant to this sentence, considered in the aggregate as a single company, would not constitute a significant subsidiary (as defined in Regulation S-X [17 CFR Part 210]) of the top registered holding company. If any financial statement required to be audited or supported by notes herein has been filed with the Commission in audited form pursuant to any act administered by it, the requirements of this form as to such audit or as to such supporting notes may be satisfied by incorporating such statement by reference, provided the written consent of the independent accountant to such incorporation is filed as a part of this report.

(c) For the purposes of this form, however, only the following schedules specified in Rule 5-04 [17 CFR 210.5-04] of Regulation S-X [17 CFR Part 210] need be filed, to the extent required by that regulation:

(i) In support of the corporate and consolidated financial statements (included in such consolidating statements) of the top registered holding company, all required schedules except Schedules II, III, IV, X, XVII and XVIII; and

(ii) In support of the financial statements (included in such consolidating statements) of each subsidiary company, which files this report pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934, all required schedules, except Schedules II, III, IV, XVII and XVIII, provided that any schedule of a subsidiary company may be omitted if the information required is set forth separately in the consolidated schedules of the parent or elsewhere in the financial statements or in the answers to any of the items of the form.

The schedules shall be examined by the independent accountant. Any required schedule may be incorporated by reference to any prior filing under any act administered by the Commission; provided that at least one copy of such prior filing has been filed with or simultaneously filed with each securities exchange on which any security of the particular system company is listed and registered; and provided further that the written consent of the accountant to such incorporation is filed as part of this report. If the information required in any schedule of a system company is contained in any schedule or schedules of such company's report to the Federal Power Commission, duplicates of such schedules with appropriate reference to this form may be used to satisfy the requirements.

(d) (No change)

(e) The elimination adjustments supporting each consolidating statement shall set forth in detail (not net) showing the adjustments pertaining to each company included in the consolidation and shall be accompanied by an explanation in sufficient detail to reveal clearly the nature of each such adjustment.

2. *Other statements.* Comparable corporate statements shall be filed for any subsidiary company in the holding company system not included in the consolidating statements required above. Such corporate statements need not be prepared and audited in accordance with the requirements of Regulation S-X [17 CFR Part 210] except where the company is a significant subsidiary and majority-owned subsidiary as defined in Regulation S-X [17 CFR Part 210].

[FR Doc.73-15800 Filed 7-31-73;8:45 am]

ATOMIC ENERGY COMMISSION

[10 CFR Part 71]

PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIAL

Form for Shipping Plutonium

The Atomic Energy Commission is considering the amendment of its regulations in 10 CFR Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions" to require that all plutonium in quantities greater than 20 curies shall be packaged for shipment as a solid in capsules which meet the requirements for special form and shall be shipped inside packaging that meets the requirements of Part 71 for radioactive material in normal form. The proposed requirements would become effective three years after the effective date of the amendment.

In light of anticipated significant changes in the characteristics and quantity of plutonium to be transported in the future, the Commission has considered the matter of form for shipping plutonium from the standpoint of public health and safety. Existing regulations permit the shipment of plutonium in any chemical or physical form, including liquid plutonium nitrate. Using the present criteria and requirements of Part 71

dreds of plutonium nitrate shipments
c been made with no reported in-
ces of plutonium leakage from the
nent vessel.

'er, the present situation with
to plutonium transportation in
private sector is expected to change
stically over the next several years.
'easingly larger quantities of plu-
um will be recovered from power re-
r fuel. Consequently, increases in
ntities of plutonium shipped and
iber of shipments made are expected.
example, the amount of plutonium
lable for recovery is estimated to be
kg in 1973 as compared to 21,000 kg
980. In addition, the specific activity
the plutonium will increase with
ier reactor fuel burnup, resulting in
ier gamma and neutron radiation
is, greater heat generation, and
ter pressure generation potential
n plutonium nitrate solutions in ship-
g containers.

ecause of these expected changes in
onium transport and the inherent
eptibility of liquids to leakage, the
mission believes that safety would be
ificantly enhanced if the basic form
shipments of plutonium were changed
n liquid to solid and if the solid form
lutonium were required to be shipped
a package providing at least double
tainment of the contents. Such a
nge is considered to be feasible from
economic and technological stand-
nt.

The Commission's assessment indicates that there will not be a significant increase in the quantities of plutonium available for recovery in the next few years. However, the Commission believes that any change in the requirements regarding the form of plutonium for shipment should be announced promptly so that firms that design and build fuel reprocessing and fuel fabrication plants can make timely plans to accommodate this change. It is anticipated that if a solid form for shipment is required, plutonium recovered at fuel reprocessing plants would be converted to the oxide form for shipment to fuel fabricators. Based on the Commission's assessment of process and equipment changes necessary to permit shipment of plutonium as oxide, and the time when increased plutonium shipments will occur, about three years appears to be a sufficient time period. Accordingly, if the proposed amendments are adopted, the effective date would be specified as three years from the effective date of such adoption.

Pursuant to the Atomic Energy Act of 1954, as amended, and section 553 of Title 5 of the United States Code, notice is hereby given that adoption of the following amendments of 10 CFR Part 71 is contemplated. All interested persons who desire to submit written comments or suggestions should send them to the Secretary of the Commission, U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Chief, Public Proceedings Staff, by October 1, 1973. Copies of comments on the proposed amendments may be examined at the Commission's Public Document Room at 1717 H Street, NW., Washington, D.C.

1. A new § 71.42 would be added to read as follows:

§ 71.42 Special requirements for plutonium shipments.

(a) Notwithstanding the exemptions in § 71.9, plutonium in excess of 20 curies per package shall be shipped as a solid encapsulated to meet the requirements of special form as defined in § 71.4(o)(2) of this part, and shall be shipped inside an outer packaging which meets the requirements of this part for packaging of material in normal form.

(b) Authority provided in AEC licenses issued pursuant to this part for the delivery to a carrier for transport of plutonium in a liquid form in quantities exceeding 20 curies per package, shall expire on (three years from the date of adoption of this amendment).

(Secs. 53, 161, 68 Stat. 930, 948; 42 U.S.C. 2073, 2201)

Dated at Germantown, Maryland, July 30, 1973.

For the Atomic Energy Commission.

GORDON M. GRANT,
Acting Secretary
of the Commission.

[FR Doc.73-15986 Filed 7-31-73;10:47 am]

Appendix B

Part 71 Definition of "Special Form"

The 10 CFR Part 71 definition of "special form" means any of the following physical forms:

(1) The material is in solid form having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters; does not melt, sublime, or ignite in air at a temperature of 1,000° F.; will not shatter or crumble if subjected to the percussion test described in Appendix D of this part; and is not dissolved or converted into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.; or

(2) The material is securely contained in a capsule having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters, which will retain its contents if subjected to the tests prescribed in Appendix D of this part; and which is constructed of materials which do not melt, sublime, or ignite in air at 1,475° F., and do not dissolve or convert into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.

Appendix D of Part 71 lists the following tests for special form licensed material:

(1) Free Drop--A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.

(2) Percussion--Impact of the flat circular end of a 1 inch diameter steel rod weighing 3 pounds, dropped through a distance of 40 inches. The capsule or material shall be placed on a sheet of lead, of hardness number 3.5 to 4.5 on the Vickers scale, and not more than 1 inch thick, supported by a smooth essentially unyielding surface.

(3) Heating--Heating in air to a temperature of 1,475° F. and remaining at that temperature for a period of 10 minutes.

(4) Immersion--Immersion for 24 hours in water at room temperature. The water shall be at pH 6-pH 8, with a maximum conductivity of 10 micromhos per centimeter.

Appendix C

Preparation of Plutonium Dioxide from Plutonium Nitrate

C.1 Process Operations

The principal method used for converting plutonium nitrate to ceramic-grade plutonium dioxide is the precipitation of plutonium as the oxalate followed by filtration and calcination. A typical flowsheet for this process is shown in Figure C-1.[1] For purposes of this analysis, the capacity of the conversion facility is postulated to be a feed rate of 340 liters of $PuO_2(NO_3)_2$ per day with a plutonium concentration in the feed stream of 150 grams per liter which corresponds to processing 50 kg Pu/day (the design basis for the Plutonium Product Facilities of the Barnwell Nuclear Fuel Plant).[2] The solution is fed into a precipitation vessel. Hydrogen peroxide is added for valence adjustment, either before or during the addition of the precipitating agent - oxalic acid. As the oxalic acid and peroxide are added to the plutonium solution, plutonium oxalate is precipitated and oxygen is evolved (7200 l/day). The slurry is removed from the precipitation vessel and filtered. The cake is then washed with a mixture of nitric acid and oxalic acid. The washed cake is removed for calcining. Potassium permanganate ($KMnO_4$) is added to the filtrate to

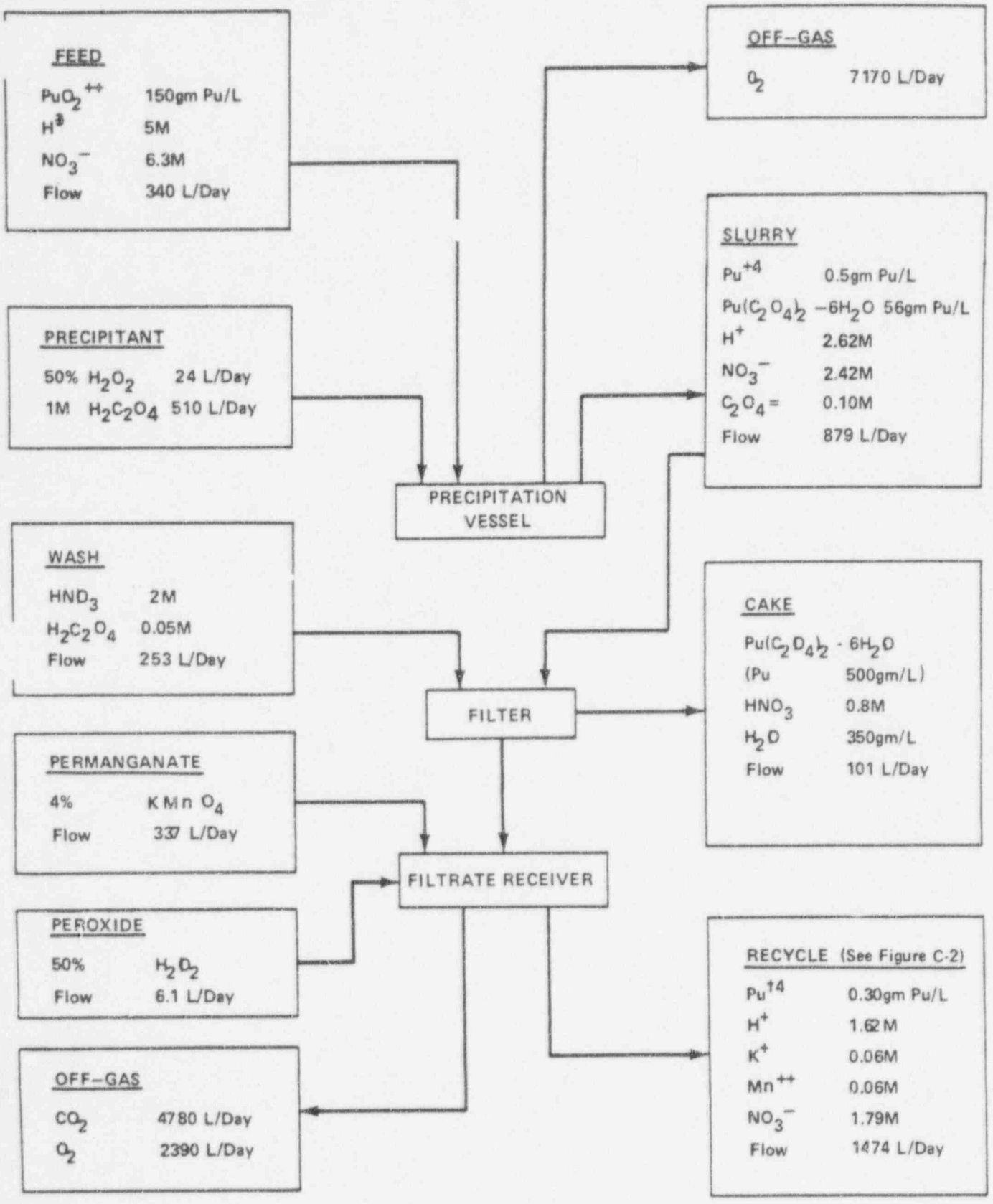

Figure C-1. Flowsheet for Oxide to Nitrate Conversion

oxidize the excess oxalate to carbon dioxide (4780 l/day) and hydrogen peroxide is added to react with excess permanganate to form water and oxygen (2390 l/day). Approximately 1470 liters/day of filtrate is generated and sent to a recycle line to recover the small quantities of plutonium (0.3 gm/liter). This step is discussed later.

Approximately 100 liters of plutonium oxalate hexahydrate cake are produced each day and this cake contains 500 gm Pu/l, 350 gm H_2O/l and 50 gm HNO_3/l. The cake contains approximately 99% of the plutonium originally present in the feed. The damp $Pu(C_2O_4)_2 \cdot 6H_2O$ is converted to PuO_2 in a calciner; calcination is accomplished in the presence of air to aid carbon removal and to ensure complete conversion to PuO_2. The off-gases contain H_2O, CO, CO_2 and NO_x from the carry-over of acid. Assuming conservatively that 10^{-3} of the processed plutonium becomes airborne and impacts three stages of high efficiency air filters (each capable of removing 99.95% of the particulates), approximately 2.8×10^{-3} μCi/day of plutonium would be released. The value of 10^{-3} is considered to be a very conservative estimate of the quantity of plutonium which impacts the HEPA filter banks since: the subject operations generally involve wet processes; the operations are generally not as susceptible to the generation of airborne particles of plutonium as grinding,

machining, etc.; and plutonium particles are dense and tend to settle relatively rapidly. The specific activity of plutonium was taken to be 0.46 Ci-α/gm which corresponds to a burnup of 35,000 MWD/MT, a relatively high burnup.

The quantities of waste generated in the reprocessing plant make waste-recovery operations an important aspect of the plant. The availability of scrap recovery systems at the plant as well as the value of plutonium and incentives to minimize the volume of contaminated waste will result in efforts to recover the plutonium contained in the treated filtrate produced in the oxalate precipitation step. In the recovery operations, the plutonium is purified and concentrated in a solvent-extraction system. These operations are shown in Figure C-2 and include feed preparation, two-phase contacting for extraction,scrubbing and stripping, product concentration,solvent treatment and waste disposal.[3] Based on a feed rate of 1470 liters per day of treated filtrate, these operations will produce approximately 5 liters per day of plutonium (100 gm/liters) contained in a dilute nitric acid solution. This solution is mixed with the feed material for the oxalate precipitation step.

The final waste losses from both aqueous and organic raffinate

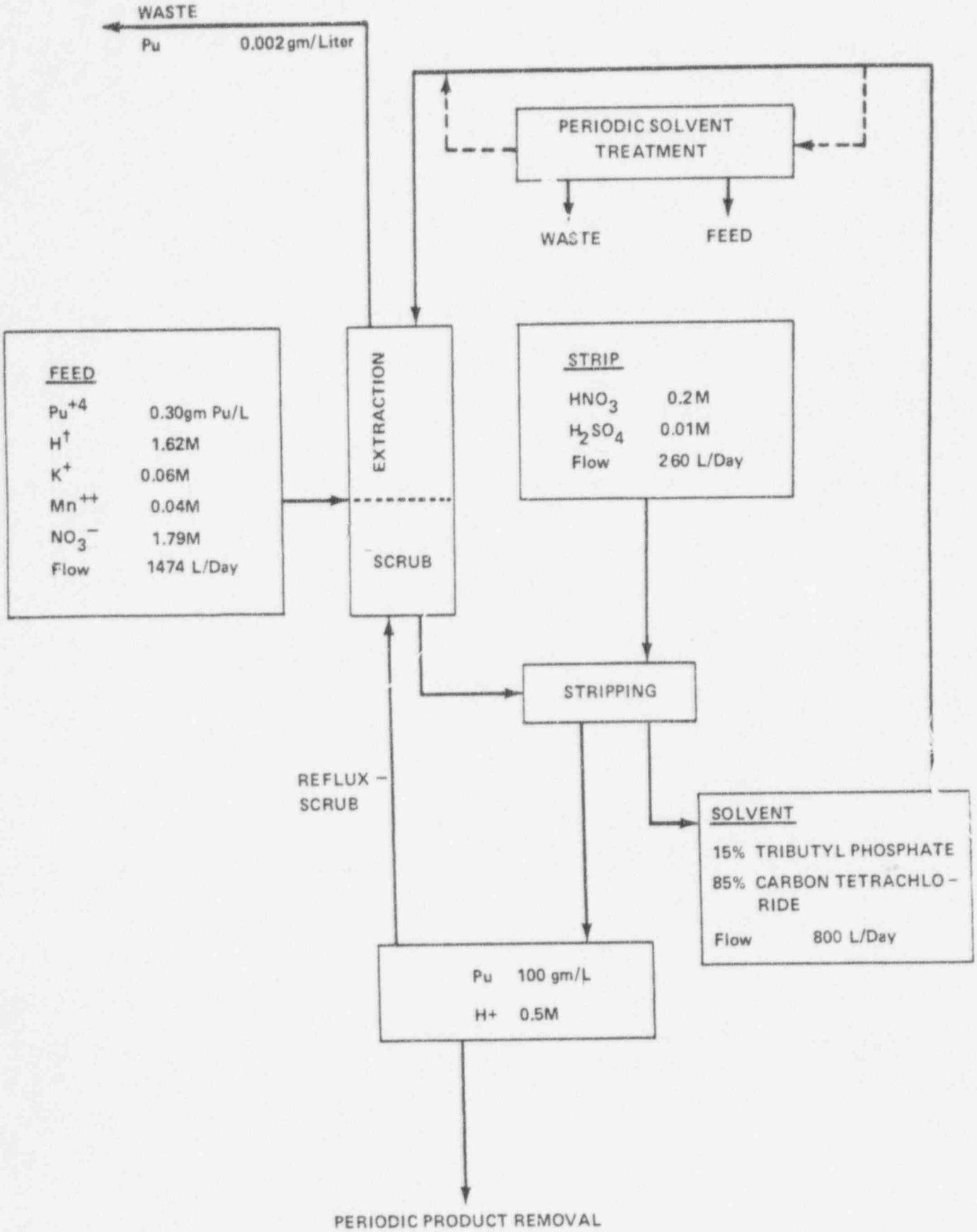

Figure C-2. Flowsheet for Solvent-Extraction System

streams represent about 0.6% of the feed.[4] The wastes generated will contain approximately 0.002 gm/l of "unrecoverable" plutonium. Approximately 1300 liters of waste per day will be generated. It is assumed that this waste will be neutralized with sodium hydroxide and mixed with cement at a weight ratio of cement to waste of about 55/45. The mixture is poured into 30-gallon inserts in 55-gallon drums, stored on site or shipped to a site authorized to receive such wastes. On the basis that the resulting concrete has a density of about 2 gm/cc, approximately 7 waste drums would be filled per day.

C.2 Capital and Operating Costs

As mentioned in Section 4, the Staff's cost estimates were based on AEC information and do not necessarily reflect costs at individual facilities nor do they reflect industry charges. We believe the important aspects to consider are the comparative costs involved and the impact of any additional costs in the total fuel preparation costs.

C.2.1 Costs of Converting Plutonium Nitrate to Plutonium Dioxide at the Reprocessing Plant

The reprocessing plant is considered to have an annual throughput of 15,000 kilograms of plutonium. This is approximately the size of the Allied-Gulf Nuclear Services facility at Barnwell, South Carolina. As in the above section, it was assumed that the conversion would be done

using the oxalate precursor method. The waste streams from this process would be recycled to the reprocessing plant with capital cost assessed for pretreatment only. Because of the problems of handling powders efficiently in relatively large quantities in restricted geometries, $500,000 was allocated for research and development.

Based on these assumptions, it is estimated that a capital cost would be incurred by the reprocessor of $3,100,000. Using a 24% annual amortization rate, the cost attributable to capital costs, at 15,000 kg/yr throughput, is $50/kg Pu. Annual operating costs are estimated to be $1,200,000, adding $80 cost to each kilogram of plutonium converted. Thus, the total cost per kilogram for conversion by the reprocessor is $130.

C.2.2 Costs of Converting Plutonium Nitrate to Plutonium Dioxide at the Fuel Fabrication Plant

Under the present regulations the fuel fabricator may receive plutonium nitrate for conversion to the oxide. For the present analysis, the fuel fabricator is again considered to have a throughput capacity of 25 kg plutonium per day and a total of 5,000 kilograms of plutonium is reconstituted to plutonium nitrate per year.

It is assumed that the conversion would be done using the oxalate precipitate flow sheet. Because of the problems of handling powders efficiently in relatively large quantities in restricted geometries, $300,000 was allocated for research and development, a smaller amount than that assumed for the reprocessor because of the smaller capacity of the fabricator's conversion system.

Based on these assumptions, it is estimated that a capital cost of $2,000,000 would be incurred by the fuel fabricator. Using a 24% annual amortization rate, the cost per kilogram of plutonium attributable to capital costs is $100. Annual operating costs are estimated to be $1,000,000, adding $200 per kilogram plutonium to the cost. Thus, the total cost for conversion of plutonium nitrate to plutonium dioxide by the fuel fabricator is $300 per kilogram plutonium.

C.3 References to Appendix C

1. Harmon, K. M., B. F. Judson, W. L. Lyon, R. A. Pugh, and R. C. Smith, "Plutonium Reconversions," In: Reactor Handbook, Volume II, Fuel Reprocessing, (Editors S. M. Stoller and R. B. Richards) Interscience Publishers, Inc., New York, N. Y. (1961) p. 449

2. Allied-Gulf Nuclear Services, Barnwell Nuclear Fuel Plant, Preliminary Safety Analysis Report, Appendum No. 7, Plutonium Product Facilities, Docket No. 50-332, July 2, 1973.

3. Cleveland, J. M., "Plutonium Recovery and Waste Disposal," In: Plutonium Handbook - A Guide to the Technology (Ed. O. J. Wick) Gordon and Breach, Science Publishers, New York, N. Y. (1967) p.582.

4. Judson, B. F., "Performance of a Plutonium Reflux Solvent Extraction System," In: Symposium on the Reprocessing of Irradiated Fuels, Brussels, Belgium, May 20-25, 1957, USAEC Report No. TID-7534, p. 299.

Appendix D

Reconstitution of Plutonium Nitrate from Plutonium Dioxide

D.1 Process Operations

The basis for the analysis in this statement concerning the reconstitution of plutonium nitrate from plutonium dioxide is a fuel fabrication plant with a throughput capacity of approximately 25 kg of plutonium per day. The following assumptions concerning the feed material and process requirements are made: a) the plutonium dioxide as received would be relatively easy to dissolve such as that calcinated at about 750°C; b) the dissolved plutonium will require purification; and c) minor scrap processing capability exists.

A process flow diagram for reconstituting plutonium nitrate from plutonium dioxide is shown in Figure D-1. The conversion process at the reference plant can be subdivided into five operations: PuO_2 receiving and storage, PuO_2 dissolution, plutonium solvent extraction purification, plutonium nitrate product concentration, and waste treatment and disposal. The process steps are summarized in the following. The doubly-canned PuO_2 is removed from the shipping container. The outer can is removed and the inner can containing the PuO_2 is sent to interim storage, following confirmation of the shippers

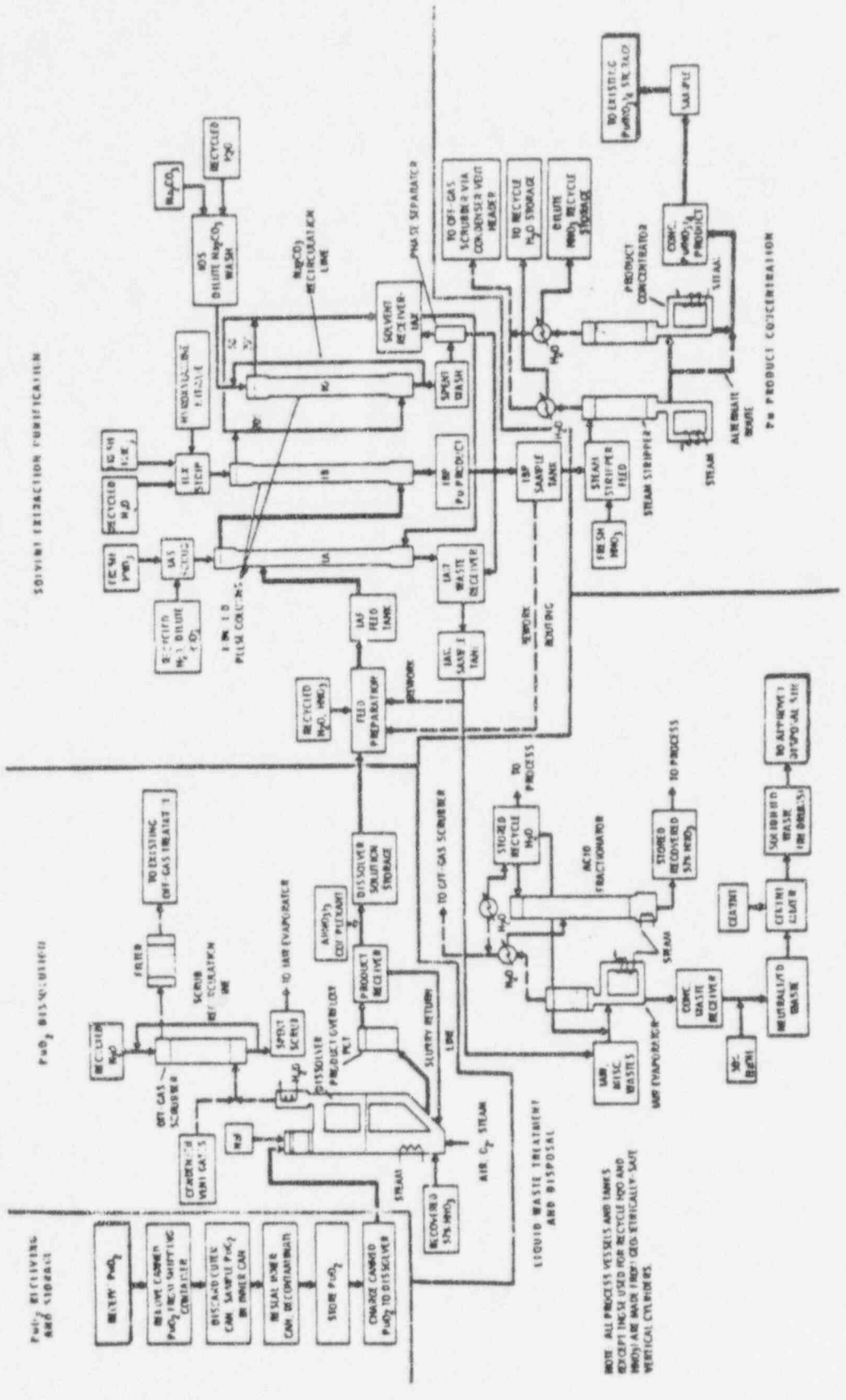

FIGURE D-1

Overall Process Flow Diagram for Dissolution and Purification of PuO_2

accountability figures. On demand, the canned PuO_2 is charged to the dissolver where it is dissolved by concentrated HNO_3 containing a small amount of HF. The dissolver product is processed by solvent extraction to remove iron, fluoride and other impurities. The purified plutonium solution is steam stripped to remove dissolved and entrained solvent and concentrated to the desired plutonium nitrate concentration.

Off gases from the dissolver consist mostly of sparge gases and the oxides of nitrogen generated during dissolution of the iron cans. A condenser is installed at the top of the dissolver recirculation leg to condense the vapors leaving the dissolver and to recover some of the oxides of nitrogen as nitric acid (which is recycled in the process). The uncondensed vapors are directed to a scrubbing tower to remove physical entrainment and additional oxides of nitrogen. The vapors leaving the scrubber are cooled and passed through three stages of HEPA filters (which are each capable of removing 99.95% of the entrained particles) before being routed to the building exhaust gas system.

Aqueous waste streams are processed to recover and recycle virtually all of the nitric acid and water used in the operation. The remaining wastes from the various process steps,

after sampling to confirm acceptably low plutonium content, are combined and fed to an evaporator. Overheads, containing a small amount of HF, are condensed and fed to the center of a packed acid fractionating column. This column is designed to produce 0.01 M HNO_3.

A portion of the condensate is used as reflux in the fractionator tower and a larger portion is returned to the evaporator to reduce the concentration of nitric acid in the evaporator bottoms. The remainder is routed to a storage tank for reuse.

The bottoms from the waste evaporator will contain virtually all of the metal impurities introduced to the process plus the excess water and nitric acid introduced with non-recycled feed streams. The concentrated waste is neutralized, solidified, packaged in 55-gallon drums, and stored on site or shipped to a site licensed to receive such materials.

As in Appendix C, it was assumed conservatively that 10^{-4} of the processed plutonium becomes airborne and impacts three stages of high efficiency air filters (each capable of removing 99.95% of the particulates). Based on this and a specific activity of 0.46 Ci-α/gm plutonium, approximately $1.7X10^{-8}$ μCi/sec will be released.

D.2 Costs of Reconstituting Plutonium Nitrate Solution from Plutonium Dioxide at the Fuel Fabrication Facility

As mentioned above, the fuel fabrication facility is considered to have a throughput capacity of 25 kg plutonium per day. In this hypothetical case, it is postulated that a total of 5000 kilograms of plutonium per year would be reconstituted to plutonium nitrate. Because of the presence of fluoride ions required for ready dissolution of plutonium dioxide, it is assumed that, after dissolution, the plutonium solution would be purified by solvent extraction. The solvent extraction operations are considered to be a part of an already existing scrap recovery capability at the fabricator's plant. Thus, half of the cost of the wet scrap recovery facility is charged to purification of the dissolved plutonium dioxide, the other half being charged to scrap recovery.

Based on these assumptions, it is estimated that a capital cost of $1,000,000 would be incurred by the fabricator. An additional capital cost of $1,000,000 would be required, but would be allocated to wet scrap recovery, since plutonium scrap recovery operation is an important component of the fabrication plant whether or not plutonium dioxide would have to be dissolved. Using ta 24 annual amortization rate, the cost per kilogram

of plutonium attributable to capital costs is $50.00. Annual operating costs are estimated at $700,000, adding $140 per kilogram to the cost, based on the total cost for preparation of plutonium nitrate solution from plutonium oxide by the fuel fabricator is $190 per kilogram plutonium.

Appendix E

Americium in Plutonium

The Staff has considered the ramifications of the presence of americium in the plutonium received by the fuel fabricator. Americium grows into stored plutonium by decay of Pu-241. Approximately 0.5% of the Pu-241 or about 0.075% of the total plutonium (based on 15% Pu-241) decays into Am-241 each month. Accumulated americium is normally removed along with fission products and other actinides during fuel reprocessing such that the freshly prepared plutonium product from a fuel reprocessing plant is essentially free of americium.

Am-241 undergoes alpha decay with a 458 year half-life. That alpha decay is accompanied by an extremely abundant yield of soft (66 kev) gamma rays which must be taken into account in controlling personnel exposure to radiation. Although probably not justified for core neutronics reasons, removal of accumulated Am-241 prior to fuel fabrication would be necessary where the plutonium has been stored for several years and where it is to be fabricated in an essentially unshielded facility. Obviously, processing of the oxide for americium removal would be more involved than that for nitrate solutions since the oxide would first have to be dissolved.

In most cases, however, no such processing will be required since modern fabrication facilities will, of necessity, be designed to control both gamma ray and neutron exposures due to the presence of

large quantities of Pu-238 and Pu-240 in the high-burnup plutonium which will be handled. Hence, the presence of significant quantities of Am-241 will be of little consequence. Also, much of the early plutonium which may be placed in interim storage will be derived from relatively low Pu-241 contents and, hence, relatively low accumulations of Am-241. It should be recognized that because of the value of plutonium, there would be an economic incentive to not store the material for any length of time if it could be avoided. If extended storage of oxide does occur and removal of the americium before fuel fabrication is desirable or necessary, the impact of the proposed rule making would be that the fuel fabricator would have to redissolve the oxide to form the nitrate. Section 4 shows that the environmental and economic costs of the additional step are relatively small. The above discussion applies also to the removal of Pu-238 daughters.