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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 2 7 1980

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

Mr. Roy T. Upton
SVC 3/37 FA
APO NY 09352

Dear Mr. Upton:

This is in reply to your letter of April 5, 1979 to the Nuclear Regulatory Commission about nuclear power. I am sorry for the long delay in responding, but we have been very busy with the aftermath of the Three Mile Island accident.

In regard to your question about the percentage of electricity produced by nuclear plants in this country, the answer is that 13% of the electrical energy generated in 1979 came from nuclear power plants.

As to your question about whether the Rancho Seco plant in California will be closed down, the answer is that the plant was shut down on April 28, 1979, in order to make immediate modifications found to be necessary as a result of the Three Mile Island accident. An NRC Order of May 7, 1979, confirmed the necessity of shutting the plant down for this purpose. On June 27, 1979, the NRC found that satisfactory compliance with these requirements permitted resumption of operation. Additional modifications of a long-term nature are being made.

With regard to your questions about cases where fuel rods or valves have been found to be faulty, you may be interested in the enclosed excerpt on "Quality Assurance" from the NRC Annual Report for 1979, which discusses efforts to improve QA programs by all organizations performing work that is important to safety. The waste tanks at Hanford, Washington, that you mentioned are the responsibility of the Department of Energy.

With regard to the safe handling of plutonium, enclosed for your information are excerpts on "Radiobiological Hazards of Plutonium" and "Means for Mitigating Adverse Environmental Effects" from NRC report NUREG-0002 of August 1976.

Every effort is being made to protect the health and safety of workers and of the general public at all nuclear plants that are currently in operation or that may start operating in the future.

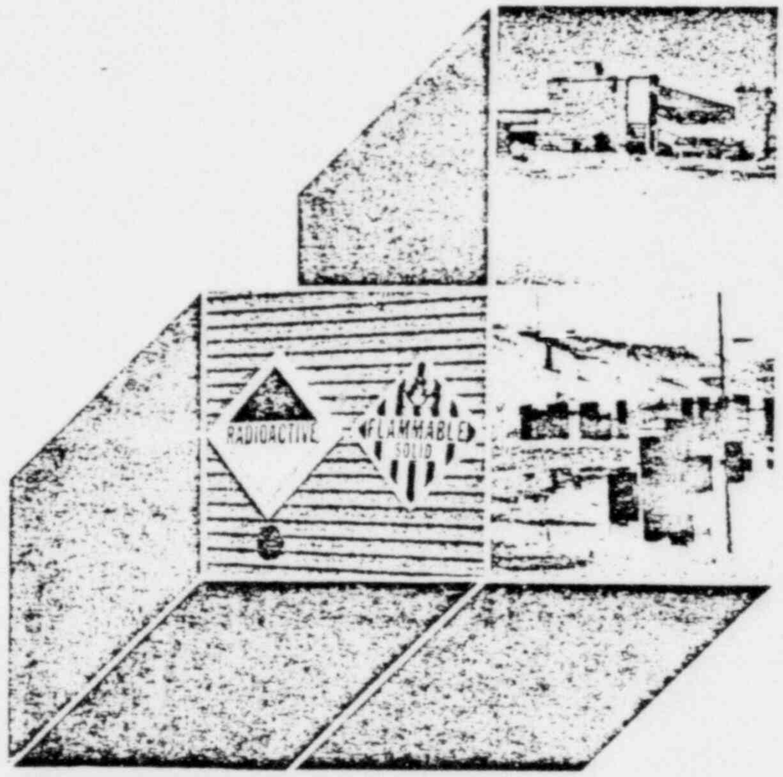
Sincerely,

Harold Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures:
As stated

1979 Annual Report



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Generic Study on Asbestos Fibers. Because of national concern over the potential carcinogenicity of airborne asbestos fibers, NRC sponsored a study by the Argonne National Laboratory to determine more precisely the basis of concern over the use of asbestos fill material in power plant cooling towers. The final report, "Asbestos in Cooling-Tower Waters" (NUREG/CR-0770), was published in March 1979. The study concluded that the concentration of fibers found in a number of power plant effluents would not constitute a health hazard.

Other Information on Ecological Impacts. Other NRC studies under way which will improve the information base for assessing ecological impacts are:

- The relationship between shipworm abundance and distribution at Barnegat Bay in New Jersey and changes in temperature and salinity caused by the operation of the Oyster Creek Nuclear Station.
- The ecological significance of fish impingement on the intake screens of the Arkansas Unit One Nuclear Station.
- The toxicity and environmental importance of chlorine and heavy metal discharges in the effluents of nuclear power plants, the frequency and significance of pathogenic amoebae in cooling systems, and quantification of mortality by entrained organisms in once-through condenser cooling systems.
- The application of aerial remote sensing techniques to routine terrestrial monitoring, and the use of reconnaissance level information for evaluating potential impacts of alternative sites.

Meteorological Measurement and Prediction. During 1979, a survey study sponsored by the NRC was completed by the Brookhaven National Laboratory on the state-of-the-art in assessing atmospheric diffusion conditions in coastal regions. The study identified meteorological measurement programs, test conditions, and needs for additional research to avoid underestimating concentrations in the event of accidents at reactor sites in the coastal zone.

The staff also sponsored a state-of-the-art survey of the transport and diffusion of hazardous materials at the Los Alamos National Laboratory. The purpose of the study was to identify modeling requirements of either buoyant or sub-buoyant plumes resulting from releases, including explosions, of hazardous materials. The summary also indicated research needs.

The staff sponsored technical assistance by the Naval Surface Weapons Center on the assessment of the state-of-the-art regarding the potential for missiles to become airborne in tornadoes. The principal purpose of this study was to determine whether the types of missiles the staff routinely postulates for purposes of assessing reactor design are adequate. The study concluded that several missiles specified by the staff would be unlikely to fly in the event of a severe tornado. As a result of these studies, the staff is reconsidering its present criteria.

Improved Interfacing with Utilities Regarding Meteorological Data. The staff has standardized the format for reporting meteorological data collected at reactor sites for reactor licensing. In the past, summarized data were required for consideration in reactor licensing, but the format for such information was not specified. Improved data acquisition recording systems in the private sector, and the need for standardization in the NRC's consideration of meteorological data, prompted the specification of a standard format for reporting on-site meteorological data on magnetic tape. Subsequent to the specification of the standard format, receipt of magnetic tape from individual reactor sites has expedited evaluations by the staff and has reduced errors in data handling.

Standardization of Meteorological Assessments for Accidental Releases and Routine Releases. During 1979, the staff developed and promulgated computer codes for assessing meteorological conditions following an accident and for routine releases. The publication of these computer codes and reference to them in NRC standards is expected to facilitate both the industry and staff's efforts in future licensing situations.

Improved Access to Agencies' Water Data. During 1979, the staff established and implemented direct computer access to EPA's STORET and the USGS's WATSTORE computer information and retrieval systems. Both of these systems allow rapid access to significant water-related data collected at many locations around the country. The access to these systems by NRC has allowed more speedy and accurate evaluations of both safety-related and environmental subjects.

Installation of Computer Information Retrieval System for Environmental Data. During the past year, a computerized document control system (known as TERA) was installed in NRC. This system will allow the professional and administative staff to search for and retrieve NRC documents, including environmental data from the files more efficiently than before (see Chapter 14.)

Quality Assurance

The application of disciplined engineering practices and thorough management and programmatic controls to the design, fabrication, construction, and operation of nuclear power plants is essential to the protection of public health and safety and of the environment. Quality Assurance (QA) provides this necessary discipline and control. Through a QA program that meets NRC requirements, all organizations performing work that is important to safety are required to conduct work in a preplanned and documented manner; to independently verify the adequacy of completed work; to provide records that will confirm tne acceptability of work and manufactured items; and to assure that all individuals are properly trained and qualified to carry out their responsibilities.

Each NRC licensee is held responsible for assuring that its nuclear power plants are built and operated safety and in conformance with the NRC regulations. In addition, the NRC has several specific QA responsibilities. First, it has a responsibility for developing the criteria and guides for judging the acceptability of nuclear power plant QA programs. Second, it has a responsibility for reviewing the QA programs of each licensee and its principal contractors to assure that sufficient management and program control exist. Finally, NRC inspects selected activities to determine that the QA programs are being implemented effectively.

Where QA programs are found deficient, the NRC requires appropriate upgrading. In those cases where the QA program is not being properly implemented, the NRC uses enforcement authority as necessary to achieve proper implementation. If a generic QA problem develops, improvements in QA programs are made industry wide.

Through the NRC topical report program, the industry has widely adopted standardized QA programs which can be used on new projects without a new review. As of the end of the fiscal year, a total of 38 topical reports on quality assurance from manufacturers of nuclear steam supply systems, architect-engineering firms, constructors, and utilities have been found acceptable by the NRC and other reports are under review.

NRC is engaged in activities, also under the topical report program, that are intended to minimize or eliminate the need for redundant audits of suppliers without reducing the confidence that work is proceeding satisfactorily in accordance with regulations. NRC is in the process of reviewing a topical report describing the ASME certification and inspection program which, if found acceptable, could be endorsed as a "third party" audit program. Successful achievement of this objective should further reduce the need for pre-award audits and for yearly programmatic audits by purchasers.

In an effort to improve QA, the acceptance criteria contained in Section 17, "Quality Assurance," of the Standard Review Plan, NUREG-75/087, which serves as the basis for determining the acceptance of QA programs, were updated to provide additional QA controls to give further confidence in the acceptability of QA programs.

Since TMI and other incidents, the overall structure for determining and acceptable QA program, including the capabilities and qualifications of individuals performing quality-affecting activities, are undergoing a review and evaluation to identify areas where further improvements can be made.

Systematic Evaluation of Operating Reactors

The Systematic Evaluation Program (SEP) staff is responsible for the review of 11 older licensed operating power reactors, applying current licensing criteria, and for documenting the results—including the need for any necessary plant changes. The major objectives of the SEP are set forth in the 1978 NRC Annual Report, pp. 59 and 62.

Phase I of the SEP, the development of a list of topics to be used in performing the systematic evaluations, has been completed. As a result, a comprehensive list of topics and definitions of staff saftey objectives, together with a review procedure that considers the effect of these topics on Design Basis Events, were developed. Phase II of the SEP, the actual evaluation of the eleven older facilities, was approved by the Commission in November 1977 and is now scheduled for completion by May 1982. The original completion date had been January 1981. The principal reasons for the slippage is the fact that the level of effort was underestimated and the other, higher priority efforts—such as response to the TMI-2 accident and equipment qualification reviews—have diverted significant manpower from the SEP effort. Steps have been taken to address these concerns by establishing an Assistant Director for SEP and by the dedication of additional manpower to the program.

Topics not applicable to a plant design or under generic review have been deleted from the plant topic lists. Of the remaining topics for each plant, more than 50 percent are in various stages of review. This effort has progressed to the point where facility Design Basis Event (DBE) reviews, which directly constitute another 25 percent of the topics, have been started concurrent with the review of the remaining plant-specific topics.

The DBE reviews will become the basis for determining the capability of a plant to properly respond to postulated accident/incident scenarios and the need for conformance to current licensing criteria. Most topics and all DBEs will be integrated into a final assessment for each facility to determine the overall requirements for facility upgrading.

One of the major topics in the SEP involves seismic design considerations. Seismic design criteria evolved significantly during the period 1956 to 1967, during which the 11 SEP facilities received their Construction Permits. Consequently, the seismic designs of these plants vary considerably.

NUREC-0002

Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors

HEALTH, SAFETY & ENVIRONMENT

EXCERPTS

August 1976

Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

pronounced by the fact that plutonium, on the average, releases more neutrons per fission than uranium, and thus increases the number of neutrons available to be absorbed. The cross section behavior of plutonium isotopes causes the various coefficients of reactivity (moderator temperature, fuel temperature, and void) to be more negative for plutonium systems. This is a favorable feature from a safety standpoint, but adds to the complexity of computing these coefficients. The presence of several fissile and fertile isotopes of plutonium also increases the complexity of computing the buildup, decay, and burnup of the higher isotopes. A great deal of the special research and development effort on plutonium recycle has gone into developing core behavior data to make calculations more precise. The success of these efforts is confirmed by the fact that the more complex plutonium uranium reactor core performance data can now be calculated with an accuracy approximately equal to that for the cores fueled with uranium only. The reactor core characteristics are discussed more thoroughly in CHAPTER IV, Section C-3.0.

2.3 The Chemistry of PuO_2

Plutonium dioxide[1,3] is the material that will be used in the mixed oxide fuel of LWR's if plutonium is recycled. It has a melting point of about 2,390°C and is very stable. For production purposes, purified plutonium nitrate is usually converted to PuO_2 by decomposition of precipitated Pu (IV) oxalate by heating at temperatures of 450°C-800°C in air. PuO_2 may be prepared by thermal decomposition of other compounds of plutonium:

- Decomposition of plutonium (IV) peroxide by heating to above 200°C
- Thermal decomposition of Pu (IV) nitrate at above 225°C
- Calcination of Pu (IV) iodate at 600°C in air
- Calcination of Pu (IV) sulfate at 800°C
- Calcination of plutonium (IV) hydroxide

2.4 Radiobiological Hazards of Plutonium[6]

Before the world's supply of plutonium was as much as one gram, research on the radiobiological hazards of plutonium had been started. The radiological hazards of plutonium have been the subject of continuing research by many scientists during the past 30 years.

The recycling of plutonium would have little effect on the exposures to the public from external radiation. However, in working with the material precautions must be exercised to avoid inhalation or ingestion of plutonium bearing materials because plutonium is extremely radiotoxic if taken into the body.

Since external radiation associated with plutonium can be readily controlled by relatively thin shielding in work areas or around handling equipment, the most important measures to protect workers and the public are precautions to prevent release and subsequent intake into the body. The most likely route of intake is by inhalation. Less likely routes of intake are

- Through the skin or through wounds

- Ingestion and subsequent absorption from the gastrointestinal tract

The route of entry into the body has a significant effect on deposition and distribution in the tissues and bone. CHAPTER IV, Section J, includes a detailed discussion of the radiobiological hazards associated with plutonium, including effects from skin absorption and internal deposition in the blood stream, in the lungs, and in body organs and bone. It is important to note that plutonium is not easily retained in the body fluids--solubility in water at room temperature is only about 20 micrograms per liter. In slightly alkaline conditions, such as would be found in the small bowel, for example, plutonium forms extremely insoluble hydroxides and hydrous oxides.

Since the advent of the Atomic Energy Commission programs in the United States, a number of people working with plutonium have accumulated quantities of plutonium measurable by urinary excretion. Case histories and data developed in thorough physical examinations of 37 individuals who had systemic burdens estimated to be in excess of the National Council of Radiation Protection (NCRP) established maximum permissible level (MPL) of 0.04 μCi of plutonium are available. Under observation for periods ranging from 5 to 25 years since exposure,[7] the cases concern persons who were exposed during the Manhattan Project or subsequently in government facilities operated by contractors. Twelve individuals in whom the original plutonium intakes occurred 23 and 24 years ago have been kept under surveillance and subjected to periodic careful and thorough examinations. These individuals have experienced no changes in their physical conditions not attributable to the natural aging process. Similarly, in the several cases where systemic burdens approached or were greater than 0.04 μCi that have occurred more recently in England, there have been no reports of lung, lymph node, liver or bone morbidity attributable to plutonium deposition. Although the number of cases is too few to support reliable extrapolations to the biological consequences of plutonium, this evidence suggests that the MPL for plutonium is conservative.

A study of indigenous and experimental animals kept for long periods in areas heavily contaminated with plutonium indicates that direct uptake of plutonium was small. Plutonium uptake by plants from soil and growth media has been investigated in the field and in the laboratory under a variety of conditions. The concentration of plutonium in plants on a dry weight basis was never more than one thousandth of that in the growth medium, and only about one ten thousandth of that in the soil. The fraction of available plutonium absorbed from the gastrointestinal tract of animals grazing on contaminated vegetation is less than one ten thousandth the total intake of the element and measurements of plutonium transfer from the blood stream to milk suggest a further reduction in plutonium concentration by another factor of at least 10. Consumption of animal products by man will introduce another reduction factor of at least 10^{-4} in the plutonium concentration entering the systemic circulation, except in the very young infant where the factor may approach 0.01.[8] It appears, therefore, that the possibility of transfer of plutonium from soil to man by way of the food chain is negligible.

Studies at the Nevada Test Site for a period of 10 years following the 1955-1957 series of high explosive detonations involving plutonium, show that the uptake of plutonium by plants increases over the years. Although conclusive evidence was not obtained, it appears that the increase in plutonium uptake might be due to continued development of larger and deeper root systems, and to the action of natural chemical complexing agents present in soils that make plutonium more soluble. Although the increase in plutonium uptake is measurable, the levels are so low that, even with the increase, ingestion of plutonium through the consumption of plants would not represent a significant pathway to human exposure.[9] For example, during a 5-year period of growing test crops in the contaminated soil, the accumulation of plutonium in plant tissues increased from 3 d/m.g* (dry weight) to about 23 d/m.g. Even so, consumption of food grown in such contaminated soils has caused only extremely low plutonium uptake in the body. This conclusion is based on measurements of the tissues of persons exposed to fallout from past nuclear weapons tests, which in themselves have resulted in the production and dispersal of about 320,000 curies of plutonium.[6] These measurements also indicate a maximum plutonium concentration of $3x10^{-14}$ Ci/g in pulmonary lymph nodes. The highest concentration found in the lung was $5x15^{-15}$ Ci/g. These values also attest to the very low body uptake via inhalation in a slightly contaminated environment.

At Palomares, Spain, the nonnuclear explosion of a nuclear weapon dispersed a large quantity of PuO_2. Followup studies after an extensive cleanup campaign have not revealed any consistently measurable plutonium concentration levels in people or produce from the area, even though plutonium surface contamination levels approaching 500 $\mu g/m^2$ were plowed into the soil and in some areas, the plutonium could not be plowed under because of the rocky terrain.[6]

3.0 PLUTONIUM RECYCLE IN LWR's

3.1 Development and Testing of Mixed Oxide Fuels

The initial development of technology for plutonium recycle in LWR fuel was sponsored by the USAEC, with follow-on programs financed by utility companies and nuclear reactor manufacturers; in some cases, programs had joint sponsorship. Development of the technology of plutonium recycle in reactor fuels began with the AEC sponsored Plutonium Utilization Program (PUP) at Hanford in 1956, and is continuing, mainly with mixed oxide fuel performance demonstrations in LWR's. After supporting the PUP program at Hanford and the Saxton MOX fuel development and testing program, the U.S. Government concluded that further development of plutonium recycle technology could be carried out by industry.

*d/m.g. = disintegrations/minute/gram

CHAPTER VII

MEANS FOR MITIGATING ADVERSE ENVIRONMENTAL EFFECTS

SUMMARY

The NRC, through its regulations and licensing review procedures, ensures that licensees provide effective means to limit the adverse environmental impact of their facilities and activities to levels that are as low as reasonably achievable (ALARA).

Measures and controls applied by NRC to limit environmental impacts include the establishment of standards and guides and the thorough technical review of site selection and design bases, quality assurance plans and procedures, construction activities, operating procedures, monitoring programs, transportation, waste management, and materials and plant protection considerations. To assure protection of public health and safety, the NRC staff must make a favorable determination on all of these factors prior to authorizing any activities with special nuclear material (e.g., plutonium).

Special requirements indicated by the above reviews may be appended as license conditions to cover such items as safety limits, safety systems limiting settings, limiting conditions of operation, design features, monitoring programs, administrative controls, and safeguards procedures.

NRC enforcement procedures provide for regular physical inspections of the facilities, equipment, operations, procedures and performance data.

Analyses contained in CHAPTER IV show that there will not be significant differential environmental impacts associated with plutonium recycle, taking into acount the measures and controls that are available today to limit adverse effects.

Additional mitigating measures may be feasible in the future to further reduce the differential adverse environmental effects through siting or design improvements, timing, monitoring, restoration, etc. Such potential mitigating measures are also identified and discussed in this chapter.

1.0 INTRODUCTION

The National Environmental Policy Act of 1969, implemented by Executive Order 11514 and the Council on Environmental Quality's (CEQ) Guidelines of August 1, 197 (39 FR 20550), requires that detailed environmental impact statements clearly identify in one place the environmental effects that are adverse and unavoidable under the proposed action. The CEQ Guidelines also direct Federal agencies to include in their environmental statements, for purposes of contrast, a clear statement of how the avoidable adverse effects will be mitigated. This chapter addresses the latter issue.

Mitigation of the adverse effects identified in CHAPTER IV is a matter of course in NRC licensing practice. Through its licensing and inspection and enforcement functions, the agency routinely limits the adverse environmental impact of licensed activities to as low as reasonably achievable (ALARA) levels. For purposes of this statement, in evaluating each segment of the fuel cycle in CHAPTER IV, it has been assumed that, essentially, the technology available today will be utilized to achieve ALARA levels of impact on the environment. Thus, no credit has been taken for future technological advances. CHAPTER VI summarizes the differential environmental effects that could occur and which would be adverse and unavoidable should plutonium recycle be introduced into the LWR industry. This chapter summarizes the measures and controls now used to limit adverse effects and identifies some additional provisions that can reasonably be expected to be employed in the future. Possible future mitigating measures which could be taken to further reduce the differential adverse environmental effects--specific siting or design improvements, timing, monitoring, restoration, etc.--are identified and discussed. This chapter is not intended to be a discussion of the alternative dispositions of plutonium (see CHAPTER VIII).

2.0 PRESENT MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS

A person or organization desiring to carry out activities involving plutonium (possession, use, processing, transfer, etc.) must have a Special Nuclear Materials (SNM) license, issued by NRC. Regulations require that, where appropriate, an applicant for such a license furnish to NRC a complete description of the applicant's proposed activities, organizational structure, managerial and administrative controls, materials and plant protection controls, equipment and facilities, health and safety programs, an accident risk evaluation, and a criticality analysis. This information provides a basis for the Commission to make the following determinations: whether the applicant is qualified by reason of training and experience to use the equipment, whether his procedures for protection of health and safety are adequate, and whether the SNM in his possession is adequately safeguarded.

In conjunction with the application for such a license, an applicant must also submit a detailed environmental impact report. The report must contain sufficient information to allow the NRC staff to assess the potential environmental effects of the proposed activity, including those of construction and operation of any facility in which activities involving licensed material will be carried out. To ensure that issuance of a license will be consistent with the national environmental goals, as set forth by the National Environmental Policy Act of 1969, the staff then performs an independent assessment of the environmental consequences should the license be granted. The review process must include a balance or comparison of the environmental costs of the proposed activity versus the benefits gained, as well as consideration of the alternatives that may alter this balance.

Before authorizing plutonium recycle activities, the NRC must evaluate the safety, environmental, and materials and plant protection considerations involved and make a favorable determination on all considerations. Specific factors that can limit any adverse effects and which are considered in the safety review and analysis of the proposed activities of an applicant are: site selection for the planned facility, proposed design bases, proposed construction activities, proposed operational procedures, proposed monitoring programs, transportation and waste management plans. Plans for future decommissioning when the plant is no longer operating must be considered and adequately provided for before NRC will authorize construction of a new plant.

In addition to the licensing reviews of plans and specifications, the NRC performs inspections during construction, and later during operation, to assure that all requirements are being met. The physical inspections are performed by technical experts from the NRC field inspection staff who examine the facilities, equipment, procedures, and operating and monitoring data to assure compliance with all requirements of the NRC regulations and special conditions of the license. Items of noncompliance must be rectified by the licensee; flagrant or especially serious violations can result in NRC's requiring the facility to be shut down or imposing a fine upon the licensee. When decommissioning of a facility is proposed, NRC review of plans and inspections of performance at the site will be carried out to assure the enforcement of all regulatory requirements for protection of health, safety and the environment.

2.1 Site Selection

Since the fuel cycle involves a wide diversity of operations, it is not feasible to establish in advance all the environmental characteristics that are of critical importance for a particular function at a specific site. Thus, the details of siting are now, and will continue to be, handled on a case-by-case basis, balancing the risks associated with each combination of site and facility design against the benefits of construction and operation of the facility at that particular site. Fuel cycle facilities in which plutonium is processed are, in general, expected to be constructed on relatively remote sites. The NRC takes the following factors into consideration in determining the acceptability of a site:

- Population density and land use characteristics of the site environs

- Physical characteristics of the site, including seismology, meteorology, geology and hydrology

A site for a plutonium processing fuel cycle facility (as for all nuclear facilities) is, in general, acceptable only if its characteristics are such that the proposed facility with its engineered safety features can be constructed, operated and decommissioned thereon while:

- Presenting no undue hazard to employees, individual members of the public or the general public

- Having an acceptable impact on the environment

- Appropriately protecting special nuclear material

2.2 Design Bases

Each applicant for a license to operate a facility must submit a Safety Analysis Report (SAR) including information that describes the facility, presents the design bases and the limits on its operation, and provides a safety analysis of the structures, systems, and components and of the facility as a whole. It must also include, among other things, the following:

Descriptions and analyses of the structures, systems, and components of the facility must be provided, with emphasis upon performance requirements, the bases (with technical justification) upon which such requirements have been established, and the evaluations required to show that safety functions will be accomplished. The descriptions must be in sufficient detail to permit understanding of the system designs and their relationship to safety evaluations. For nuclear reactors, such items as the reactor core, reactor coolant system, instrumentation and control systems, electrical systems, containment systems, other engineered safety features, auxiliary and emergency systems, power conversion systems, radioactive waste handling systems, and fuel handling systems must be discussed insofar as they are pertinent. For facilities other than nuclear reactors, such items as the plant structures and the chemical, physical, metallurgical, or nuclear process to be performed, instrumentation and control systems, ventilation and filter systems, electrical systems, auxiliary and emergency systems, and radioactive waste handling systems must be discussed insofar as they are pertinent.

The SAR should describe the kinds and quantities of radioactive materials expected to be produced and/or handled in the operation and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in Part 20 of the NRC regulations.

The applicant is required to describe the managerial and administrative controls used to assure safe operation. Appendix B of Part 50, "Quality Assurance Criteria for Nuclear Power Plants," sets forth the requirements for the quality assurance program for nuclear power plants and fuel processing plants. The information on the program shall include a discussion of how the applicable requirements of Appendix B will be satisfied.

Each license authorizing operation of a production or utilization facility of a type described in Part 50 also includes Technical Specifications derived from the analyses and evaluation included in the Safety Analysis Report. Technical Specifications, where appropriate, include items in the following categories: safety limits and limiting safety system settings, limiting conditions for operation, surveillance requirements, design features, and administrative controls.

NRC regulations stipulate that radioactive materials in effluents released to unrestricted areas from licensed facilities must be kept as low as reasonably achievable. The as low as reasonably achievable concept takes into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and in relation to the utilization of atomic energy in the public interest. The limitation of adverse environmental impacts to as low as reasonably achievable levels is an important objective in the design, construction, and operation of individual plutonium recycle facilities and the associated transportation operations. Construction of the principal structures, systems, and components of plutonium recycle facilities is reviewed by NRC to determine that the design bases of the principal structures, systems, and components, and the quality assurance program provide reasonable assurance that environmental releases are limited to levels as low as reasonably achievable and that the facilities include protection against natural phenomena and consequences of potential accidents.

The design criteria of mixed oxide fuel fabrication plants recognize that the unique characteristics of plutonium require additional safety features as compared to other chemical plants. Consequently, provision is made for the multiple confinement of all plutonium bearing materials. The building ventilation system is typically divided into separate supply and exhaust systems. All process steps are performed in airtight sealed enclosures (gloveboxes) designed specifically for the safe confinement of radioactive materials. These enclosures are constructed of stainless steel with transparent window material; special airtight gloves are installed to permit manual operations while protecting workers from contact with glovebox inventories. Transfer of materials out of a glovebox is accomplished by using bagging procedures that preclude release of radioactive material into operating areas. The air in the gloveboxes is exhausted through a number of high efficiency particulate air (HEPA) filters in series effectively removing radioactive particulates before discharge to the atmosphere.

Several of the plutonium isotopes emit neutrons by spontaneous fission. Gamma radiation is also emitted in the radioactive decay of plutonium, especially from the ^{238}Pu, ^{239}Pu, and ^{240}Pu isotopes and from the ^{241}Am formed by decay of ^{241}Pu. The neutron and gamma radiations are low intensity, but when large quantities of plutonium are handled or when the plutonium is in a relatively pure, concentrated form, shielding may be required and the use of gloves in gloveboxes may be sharply curtailed to minimize radiation exposures of hands. Design criteria for MOX fabrication equipment require the use of shielding and of mechanical handling equipment where needed to protect workers.

Plutonium has a smaller critical mass than highly enriched ^{235}U and a much smaller critical mass than the low enriched uranium used in LWR fuels. Therefore, the design criteria for MOX fuel fabrication plants require special techniques for preventing accidental criticality. Safety features such as safe-geometry vessels, built-in poison controls and operating procedures to limit plutonium masses and concentrations in processing equipment are required, in combination with administrative controls, to prevent plutonium from collecting in sufficient quantities to form a critical mass.

The structures and equipment serving as confinement barriers for radioactive materials in mixed oxide fuel fabrication plants and reprocessing plants are designed to withstand forces resulting from natural phenomena, such as tornados, hurricanes floods and earthquakes.

Fuel reprocessing plants are designed to protect plant personnel and the public from inhaling, ingesting, or becoming contaminated by radioactive materials or from being exposed to radiation. The processing operations are performed within heavily shielded cells (restricted access). Processes are controlled from outside these shielded cells by remote operation from supporting galleries (limited access), stations, areas, and aisles (normal access). A control room and emergency utilities also are provided to enable the operating personnel to perform an orderly shutdown of the plant and maintain the process inventories in a safe condition, even in the event of an accident.

Process cells involve high levels of radiation and therefore have floors and walls several feet thick, constructed of reinforced concrete for adequate shielding.

Most of the process vessels within cells are designed to withstand a design basis earthquake with respect to support of the vessels and confinement of solutions within the vessels.

The reprocessing plant releases small quantities of gaseous radioactive effluents to the environment via the main process stack, which exhausts to the atmosphere about 100 meters above natural grade. Components of the radioactive effluents from reprocessing plants which contribute the largest population dose are tritium, carbon-14 and krypton-85, and these are well within permissible limits. Prior to release through the stack, gaseous effluents from the process and waste storage systems are filtered or chemically treated or both, to reduce the radioactive and chemical contents to as low as reasonably achievable levels.

The building ventilation exhaust air is routed through at least two series of high-efficiency (HEPA) filters which effectively remove radioactive particulates before discharge to the atmosphere. Excess process condensate is decontaminated by evaporation and condensation, and then the decontaminated water may be revaporized and discharged to the atmosphere through a 100-meter main stack. The process off-gases are routed through a decontamination equipment train including condensers, separators, scrubbers, absorbers, and multiple HEPA filters.

High level wastes and low level radioactive liquid wastes from off-gas systems, solvent washes, and other sources are concentrated and stored in stainless steel tanks within underground stainless steel lined vaults pending conversion to a solid form for eventual transfer to a Federal repository with other solid wastes. However, at least one proposed processing scheme calls for direct conversion of high level wastes to solid form with minimal storage as a liquid.

The cooling water discharged from the plant contains essentially no radioactive liquid effluents. All chemicals used in the reprocessing plant are retained for reuse, are consumed in the process, or are discharged to the waste storage tanks for interim storage pending ultimate solidification and transfer to a Federal repository for long term management.

The high value of plutonium, and incentives to minimize the volume of contaminated waste, give rise to efforts to recover the plutonium contained in wastes or off-specification products. Extensive scrap recovery operations are expected to be performed to minimize the quantity of plutonium requiring packaging for long term management.

2.3 Construction Activities

Many of the potential effects of construction activities of reprocessing and mixed oxide plants can be reduced by appropriate selection of a e and by applying proper construction practices and controls. For example, a site on previously industrialized land, strip-mined land, or a former power plant site would not be subject to the construction activity effects that would be encountered on farm or recreational land. Many techniques are known that can minimize wind and water erosion: protecting the bare soil by restoration of vegetation, covering with mulch, sprinkling, stabilizing with gravel, grading and shaping the spoil piles, scheduling the time that ground is disturbed to avoid critical periods such as spring thaw, conservation of topsoil to spread over exposed subsoil, and others. Some of these same methods can be used to reduce dust raised by vehicles traversing exposed soil.

Cleared woodland material may be used for commercial lumber or pulpwood, where possible. Otherwise it may be burned in accordance with local regulations.

The overburden must be stored in a way that minimizes erosion during construction, or be hauled to a sanitary landfill. At the end of construction, the stored overburden may be redistributed as top soil. Control of surface runoff is provided to minimize soil erosion and steam turbidity.

No concrete or watered cement should be dumped into nearby rivers or streams or indiscriminately dumped on land. A spoils area must be designated for the disposal of waste concrete mixtures.

Temporary buildings may be erected on the site for use during the construction of the plant. These generally are one story metal buildings that should not be objectionable if seen. Any trees located on the periphery of the site may be left intact, in which case these buildings are not readily visible from offsite roadways. Of all the facilities temporarily constructed or used during construction, the only items that protrude above the tree lines are the construction cranes. The land areas disturbed during construction are landscaped as appropriate to minimize the long term impact on the environment.

2.4 Operational Procedures

Prior to authorizing activities involving plutonium, the NRC staff performs safety, environmental, and materials and plant protection reviews of the proposed activities to ensure protection of the public health and safety.

An application for a license to possess and use plutonium will be approved only after the applicant clearly demonstrates that, among other things:

- The applicant is qualified by reason of training and experience to use the material for the purpose requested in accordance with the regulations.
- The proposed equipment and facilities are adequate to protect health and minimize danger to life or property.
- The proposed procedures are adequate to protect health and to minimize danger to life or property.

Once a license has been issued, NRC makes periodic inspections, both announced and unannounced, to assure that the licensee is operating in accordance with the license conditions and the Federal regulations. State representatives may also make inspections.

Administrative and operating procedures of licensees are designed to prevent the occurrence of accidents. The probability of accidents resulting from operator error is minimized through a comprehensive training program conducted by the licensee and reviewed by the NRC covering activities involving plutonium, and through the design safety features of plants. The training program required by NRC regulations includes courses in radiological safety and nuclear safety for all employees who work in plutonium areas.

The content of such courses typically includes discussions of: radiation measurement units, the biological effects of exposure to penetrating radiation, means of limiting exposure to external radiation, methods for prevention of internal exposure, use of protective clothing and monitoring devices, radiation safety rules and policies, the concepts of nuclear criticality, alarm systems, emergency and evacuation procedures, use of survey instruments, administrative procedures, and government regulations.

Because of the possibility of a serious accident and because of the presence of hazardous materials, each applicant must establish a plan to cope with emergencies that might arise, to protect the health of employees and the public, and deal effectively with the emergency in a timely manner.

Elements of the emergency plan include the following: each licensee is required to have an alarm system in each area containing fissionable material so that a nuclear criticality excursion is immediately detected. The following equipment must be onsite or available on call: self-contained breathing apparatus, portable fire extinguishers, battery-operated lights, portable air samplers, radiation detectors, and protective clothing. Agreements must be made with various civil and private organizations for assistance in the event of a major emergency.

2.5 Monitoring Procedures

In order to quantify any environmental effects resulting from activities involving plutonium, the licensee must maintain a monitoring program that includes the sampling and analysis of plant effluents and biota and other environmental media exposed to the effluents.

In general, an applicant is required to have ecological study programs. The initial program establishes the baseline biological, chemical, physical, and ecological data before construction begins. It is followed by field programs during the construction and operation of the facility. The programs detect any significant adverse environmental impact and permit timely corrective action. The aquatic ecology program generally includes sampling of both surface and ground waters. The floral and faunal terrestrial program generally includes the gathering of information on species identification and population density in both forested and nonforested areas.

All air effluents from process systems and process areas that contain radioactive material in dispersible form must be continuously sampled. When analysis indicates a release of radioactivity from the stack in excess of some chosen limit (usually 10% or less of the restricted area maximum permissible concentration on an annual basis, as defined in 10 CFR Part 20, Appendix B), corrective action must be taken. When an action level is reached, an investigation will be made to clearly determine the reason for the abnormal releases. If it is indicated that the abnormal release of radioactive effluents will continue, the process activity must be curtailed as necessary to correct the defect and reduce releases to an acceptable level.

2.6 Transportation

Most shipments of radioactive materials move in routing commerce by conventional transportation equipment. Therefore, shipments are subject to the same transportation environment, including accidents, as nonradioactive cargo. Although a shipper may impose some conditions on his shipment, such as speed limitations, providing an escort, etc., most of the conditions to which his shipment is subjected and the probability of his shipment being involved in an accident are not subject to his control. The public and transport workers are protected from radiation during the shipment of radioactive materials by the container designs and limitations on the contents, set according to the quantities and types of radioactivity and the standards and criteria for package design and control. Safety in transportation does not depend on special routing, although special routings are used at some bridges and tunnels to avoid possible interference with the flow of traffic if an accident should occur.

Primary reliance for safety in transport of radioactive material is placed on the packaging. The packaging must meet applicable Federal and State regulatory standards, which require that the packaging shall prevent the loss or dispersal of the radioactive content-. retain shielding efficiency, ensure nuclear-criticality safety, and provide adequate heat dissipation under normal conditions and under specified accident damage test conditions (i.e., the design basis accident). The allowable radioactive materials content of packages not designed to withstand accidents is severely limited.

Protection against external radiation is provided by limitations on the radiation levels at the outside surface of packages of radioactive materials and by storage and segregation provisions. The number of packages in a single vehicle or area is limited to control the aggregate radiation level and to provide nuclear criticality safety. Minimum separation distances from people are specified for loading and storing packages of radioactive material to keep exposures to a minimum.

2.7 Waste Management

As mentioned in CHAPTER IV, Section H, the radioactive wastes resulting from both enriched uranium and mixed oxide fuel cycles can be categorized as high level and other-than high level. The "high level liquid radioactive wastes" are those aqueous wastes resulting from the operation of the first cycle solvent extraction system and the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuels. The NRC regulations governing such high level waste management are contained in 10 CFR Part 50, Appendix F, and briefly state that:

- Facilities for the temporary storage of high level radioactive wastes may be located on privately owned property.

- A fuel reprocessing plant's inventory of high level radioactive liquid waste will be limited to that produced in the prior 5 years.

- High level liquid wastes shall be converted to a dry solid as required to comply with this inventory limitation and placed in a sealed container prior to transfer to a Federal repository in a shipping cask meeting the requirements of 10 CFR Part 71.

- The dry solid shall be chemically, thermally, and radiolytically stable to the extent that the equilibrium pressure in the sealed container will not exceed the safe operating pressure for that container during the period from canning through a minimum of 90 days after receipt at the Federal repository.

- All of these high level radioactive wastes shall be transferred to a Federal repository no later than 10 years following separation of fission products from the irradiated fuel.

- Upon receipt, the Federal repository will assume permanent custody of these radioactive waste materials, although industry will pay the Federal government a charge which, together with interest on unexpended balances, will be designed to defray all costs of disposal and perpetual surveillance.

- ERDA will take title to the radioactive waste material upon transfer to a Federal repository.

- Disposal of high level radioactive fission product waste material will not be permitted on any land other than that owned and controlled by the Federal government.

- Before decommissioning of a fuel reprocessing plant, transfer of all significant radioactive wastes to a Federal repository shall be completed.

- Criteria for the extent of decontamination to be required upon decommissioning and license termination will be developed by the NRC. Opportunity for public comment will be provided.

All safety and environmental aspects of managing high level radioactive wastes at the reprocessing plant site are controlled by the regulatory, licensing and inspection and enforcement process. 10 CFR Part 50, Appendix F, speaks generally to this point and all technical specifications regarding design and operation of the plant are defined in detail during the licensing review and stated in detail in the actual operating license. Requirements are imposed on the licensee for safe packaging design and other safety requirements with respect to transporting this solidified waste to a Federal repository.

Appendix F reflects the concept that high level radioactive waste from a reprocessing plant would be stored only temporarily at the reprocessing site, solidified and transferred to a Federal repository for disposal. ERDA's present plans are to construct a demonstration facility for disposal of high level radioactive wastes in a geologic formation. This would include surface facilities for temporary holding of waste containers prior to permanent disposal underground.

For other than high level waste, the NRC has under consideration a new rule prohibiting shallow ground burial of wastes containing transuranium alpha activity. Similar provisions are already in effect by ERDA at its burial grounds. The commercial burial grounds in the States of New York, Kentucky, South Carolina, Illinois and

Nevada are precluded from burial of transuranic waste by State action. Wastes containing transuranium elements will have to be sent to a Federal repository.

The NRC evaluation of a commercial burial site prior to making a licensing decision on acceptability involves two significant safety and environmental considerations. First, the geological, hydrological and climatological characteristics of the site must be such as to assure that buried radioactive waste will not migrate into water supplies or otherwise become available for inhalation or ingestion by man. Second, commercial burial sites must be on land owned by the Federal or a State government to assure long term control.

Quantities of plutonium bearing wastes of commercial origin are presently very limited, and have until very recently been disposed of by burial in commercial facilities. The quantity of plutonium in commercial burial grounds is relatively small and is dispersed through large volumes of material. Chemical and physical characteristics of plutonium are such that migration in soil or ground water is unlikely.

A sharp increase in the amount of plutonium contaminated waste is expected to occur if plutonium recycle in LWR fuels is authorized. For example, it is estimated that there will be an increase in the cumulative total from about 4.5 to 5.2 million cubic feet of plutonium waste containing a few thousand kilograms of plutonium accumulated by the year 2000. The methods for safe management of this waste are discussed in CHAPTER IV, Section H.

2.8 Safeguards Considerations

The NRC regulations require that information on nuclear materials safeguards be submitted with each application for a license to possess at any one time special nuclear material in a quantity exceeding one effective kilogram of special nuclear material and to use such special nuclear material for activities other than those involved in the operation of a nuclear reactor or involved in a waste disposal operation, or as sealed sources. The safeguards considerations will be discussed in detail in a separate supplememt to GESMO.

3.0 POTENTIAL MEASURES TO FURTHER MITIGATE ADVERSE EFFECTS

The nuclear industry as it now exists is the product of nearly 30 years of development. Yet it is not static--inevitably an industrial technology as complex as this, in order to be responsive to the public interest and to exploit recent advances, must undergo continual refinement and development. Additional measures to further limit any adverse effects may be possible as a result of the development of regulatory criteria or guidelines for the industry or as a result of continued or newly initiated research and development efforts leading to improved facility design features. Decisions on use of these alternatives would be made during the planning, design and licensing activities required for individual facilities. The following is a discussion of measures that could further reduce any adverse effects.

3.1 Site Selection

The staff is developing qualitative and quantitative siting criteria to assist applicants for licenses for recycle plutonium facilities in the selection of sites acceptable to the Commission, based on considerations of potential impact of design basis accidents on individuals living at or near the exclusion area boundary. The guidelines will include general criteria and requirements for reporting information relevant to most facilities, and specific radiological and distance criteria for siting recycle plutonium plants.

The expected effect of the site selection criteria will be to provide assurance that all nuclear facilities are planned with careful attention to the following items. These siting criteria are being applied in present licensing reviews and will be included in the siting criteria being developed for publication:

- The radiation dose commitment from any design basis accident of high consequence and very low probability would not exceed certain specified values for any individual at any point outside the site exclusion area.

- Land and water uses, geology, meteorology, demography and aesthetics, the ecology of the site and environs, as well as natural and cultural resources affected by the facility are considered in siting the facility.

- Protection of employees and special nuclear materials is being considered.

A possible alternative in the siting of recycle plutonium facilities is to require the centralization of fuel cycle activities in integrated fuel cycle centers. Under such an option, spent fuel would be shipped to a regional site for reprocessing and refabrication. Reload fuel would be shipped from the site to a nuclear power reactor. Such an arrangement would decrease the reliance on materials and plant protection programs and would diminish the transportation impact.

3.2 Design Bases

The NRC is continually developing ALARA design criteria to assist license applicants in the planning and designing of facilities to carry out activities involving special nuclear material. The criteria are based upon the cost and effectiveness of effluent treatment systems that could be used at plants processing plutonium bearing fuels. These criteria may require added confinement barriers and added treatment systems to decrease the amount of radioactive and nonradioactive materials released to the environment. The effectiveness of the alternate treatment systems under consideration is measured by comparing the quantities of radioactive materials released by the various systems and the relative impact of each release on the environment. The impact on the environment is assessed and compared with the radwaste treatment costs as the basis for the cost-benefit analysis which is used in the decision making process. The criteria establish as low as reasonably achievable releases from plutonium processing facilities. These guides are reviewed and updated periodically to reflect the results of continued or newly initiated research and development efforts that may lead to improved systems.

3.3 Construction Activities

Many of the potential effects of construction activities can be reduced by appropriate selection of a site and by applying proper construction practices and controls. Future improvements in such practices and controls are not tied to the issue of plutonium recycle but any improvements will be utilized by the industry.

3.4 Means for Simplifying Future Decommissioning

Advance planning in the design stages can provide features which facilitate decommissioning at some future date. Aspects of plant design which can be planned in ways which simplify decommissioning include the following:[1]

- Avoidance of inaccessible pockets and cracks in which plutonium or other activity can accumulate and from which removal would be difficult

- Provision of surfaces that are easy to decontaminate

- Provision of adequate and complete drainage in all equipment and in process areas so that decontamination solutions drain into a collection system

- Use of containment systems that prevent release of plutonium or other radioactive materials under all foreseeable circumstances. If there are no releases of radioactivity, decommissioning will require only decontamination of the interior surfaces of the process equipment exposed to plutonium or other activity and almost surely will not require restrictions on future uses of the land surrounding the facility.

These special design features facilitate decommissioning. In addition, the difficulty and cost of decommissioning activities can be reduced by operating the facility in such a way as to assure maximum confinement of plutonium and other radionuclides at all times, with prompt and complete decontamination of spills, leaks or other releases.

3.5 Operational Procedures

Process operations are continually being improved or upgraded. Should subsequent developments in the process demonstrate that substantial environmental benefits, on a cost-effective basis, can be gained from their use, modifications to individual plants may (by regulation or voluntarily) be made by the applicant. Measures which may become available through ongoing research and development programs to reduce impacts include elimination of some process steps, minimization of wastes and effluents, minimization of exposures of plant personnel, additional remoting and automation of processes, and additional shielding.

Releases of radioactivity and other pollutants from fuel fabrication facilities would be very low, as discussed in CHAPTER IV, Section D.

The potential future measures to reduce releases of radioactivity from fuel reprocessing plants are centered on use of processes for removing tritium and krypton-85 from the feed material prior to dissolution and on means for recycling essentially all liquids and gases brought into the plant. Neither tritium removal processes, krypton removal processes, nor the fluids recycle technique have been tested in plant scale operation; hence, projected improvements in fission product retention are speculative. Use of the voloxidation process for tritium removal from irradiated oxide fuels may be able to achieve retention of from 90% to 99% of the tritium. Employment of fluids recycle technique in conjunction with treatment of all effluent streams by the most effective means available is expected to provide significantly higher normal operation confinement factors* for various nuclides, or classes of nuclides.

Use of recycle in the ventilation air streams is expected to significantly reduce releases of radioactivity by greatly reducing the amount of building air that must be filtered prior to release.

3.6 Transportation

Measures which could be taken to further reduce the impact of transportation, if determined to be necessary, include minimization of the amount of material shipped, shipment on selected routings, and shipment along the shortest distance. As previously mentioned, integrated fuel cycle facilities could lessen the number of shipments of plutonium bearing materials. This alternative is discussed in CHAPTER VIII.

To reduce the likelihood and severity of accidents, shipments of plutonium could be restricted to certain speeds, roadways, times of day, and weather conditions, if considered necessary on the basis of risk analysis.

As discussed in CHAPTER IV, Section G, casks and packages for shipping plutonium bearing materials could be constructed with additional shielding to further reduce radiation dose levels at the surface of the container. Shipments of plutonium could be restricted to forms which are not dispersible. Further, the casks/packages could be designed to withstand accidents more severe than the credible accident assumptions.

*Ratio of input radioactivity to released radioactivity.

From experience and analysis of a broad spectrum of conceivable accidents and potential package damage, the conclusion has been reached that spent fuel shipping casks designed to meet the current regulatory standards for type B fissile material packages provide a high degree of resistance to damage in severe transportation accidents and breach of a cask is highly unlikely. Regulatory requirements are aimed at achieving cask designs such that the probability of occurrence of a breach is so low that the risk to the environment is acceptable.

Fire and impact are the accident conditions of principal concern. Protection against impact damage is assured when the total kinetic energy associated with a cask in motion can be absorbed by the cask or surrounding objects or both without producing a leak rate in the cask containment of greater than a specified acceptable amount. The allowable leak rate for spent fuel shipments is limited in current cask design concepts by the very small release rates allowed for ^{131}I and ^{85}Kr.

During a fire, the massive gamma shield of the cask, along with the latent heat absorption capability of the neutron shield, can provide a large heat sink both for the heat absorbed from the fire and for the decay heat from the fuel. The degree of fire protection provided by a particular cask design is, therefore, dependent mainly upon the heat capacity of the shield and the heat transfer characteristics of the cask surface exposed to fire. These are the major determinants of the length of time that a cask, which contains a given quantity of heat producing fuel, can be exposed to a specified temperature. Simply stated, the cask can absorb a given quantity of heat before internal temperatures become unacceptable. The quantity absorbed is dependent on the heat input to the cask and the time of exposure to a fire. The cask can endure very high temperatures, and consequently can withstand high heat inputs for short periods of time or lower heat inputs for longer periods of time. Any design feature that effectively increases the heat capacity of the cask shield provides additional fire protection.

In addition, administrative controls are used to mitigate the consequences of any accident involving a cask. An example of administrative controls is the establishment of emergency response teams (under ERDA leadership) that are trained, equipped, and constantly on call to cope with the consequences of accidents involving radioactive materials.

3.7 Waste Management

The other-than high level wastes generated in fabrication and other operations could be reduced in volume by techniques such as incineration, leaching or compaction, or a combination of these techniques. Such treatment involves substantial cost additions and additional safety considerations. However, it is expected that there will be an economic incentive to find ways to minimize plutonium waste generation during plant operations and thus to reduce a potential safety problem and substantial extra handling cost.

3.8 Safeguards Considerations

In order for any safeguards program to be successful in the long term, provisions must be included for continuing evaluation of changing sociological and political conditions. Accordingly, the NRC has continuing studies and evaluations in progress to assess and update safeguards measures to provide the necessary protection. Further details of the safeguards measures will be discussed in the supplement to GESMO.

REFERENCES

1. R. B. Chitwood, "Decontamination and Decommissioning of Licensed Fuel Reprocessing Plants," Proceedings of the First Conference of Decontamination and Decommissioning (D&D) of ERDA Facilities, Energy Research and Development Administration and Aerojet Nuclear Company, Report No. CONF-750827, August 1975.