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International
Nuclear
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Cycle
Evaluation

INFCE

INFCE/DEP./WG.4/61

MIXED U/Pu OXIDE FUEL FABRICATION FACILITY

CO-PROCESSED FEED, PELLETISED

FUEL

CO-CHAIRMEN/WG.4/39 (B)

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DISCUSSION PAPER
SUBMITTED BY THE
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TO
INFCE WORKING GROUP 4

MIXED U, Pu OXIDE FUEL FABRICATION FACILITY
COPROCESSED FEED, PELLETIZED FUEL

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i. GENERAL DEFINITION OF PLANT

This report describes a fuel fabrication plant using coprocessed $(U,Pu)O_2$ masterblend feed to produce fuel assemblies for LWRs. Included are the fuel fabrication process, general plant layout and description, plutonium confinement, plant operation, and status of fabrication technology. A description of a fuel fabrication plant using spiked coprocessed feed is presented as an addendum to the report. The simplified process flowsheet is shown in Figure 1.

Basic specifications that were assumed in this report are as follows:

Composition of powder feed material to plant	10% PuO_2/20% UO_2 and 100% UO_2
Plant product	PWR fuel rods and assemblies
Basic process	Dry press and sinter pellets
Nominal annual design capacity (Dual lines each 100 MTHM/yr)	200 MTHM/yr
Working days per year	250
Shifts per day	2
Internal reprocessing of contaminated scrap	
Product reject rate	10%
Low level waste treatment and solidification in concrete for off-site disposal	
Operating and maintenance philosophy:	
coprocessed fuel	remote operation, direct maintenance
spiked fuel	remote operation, remote maintenance

1.0 INTRODUCTION

Plutonium recycle in Light Water Reactors (LWR) requires the fabrication of (U-Pu)O_2 pellets utilizing reprocessed PuO_2. The PuO_2 may be a purified separate oxide or may be combined with UO_2 in a master blend (coprocessed) at the reprocessing plant. A fabrication plant description utilizing separated oxides was submitted by Belgium (Belgionuclaire) as a contribution to INFCE Group 4.B and is considered a Reference description. Only minor differences exist between separated and coprocessed processes as powder blending will be required in both.

Two conceptual fabrication facilities are discussed in this study. The first facility is for the fabrication of LWR uranium dioxide--plutonium dioxide (MOX) fuel using coprocessed feed. The fuel fabrication line is operated in an automated mode with hands-on-type maintenance. Specific features are designed into the plant and processes to provide safeguards assurance. The second facility is for the fabrication of coprocessed spiked MOX fuel. In this instance a high energy gamma emitter would be introduced into the fuel during feed preparation as a safeguard measure against diversion and illicit use of plutonium. The spiked facility utilizes the same basic fabrication process as the conventional MOX plant. In the spiked facility additional shielding is added to protect personnel from radiation exposure, all operations are automated and remote, and normal maintenance is performed remotely.

Due to the intrinsic radioactive characteristics of plutonium, particular restrictions are placed on fabrication facilities and equipment to insure that both operating personnel and the public are adequately protected. These systems and restrictions are discussed in this report.

The process used to fabricate LWR fuel is the conventional dry press and sinter process in which a master coprocessed mix containing about 10% plutonium in uranium oxide will be blended with depleted or natural uranium dioxide to the desired composition, pressed into cylindrical pellets, and densified. These pellets are loaded into Zircaloy tubes, welded, and assembled into fuel bundles for shipment to a reactor site. The process incorporates specific SNM accountability and product quality assurance measures.

Although this study is based on a conceptual design, sufficient experience and knowledge of the processes and facilities exist to assure that the dominant health and safety, safeguards, and process factors have been addressed and requirements can be fulfilled.

2.0 DEFINITION OF THE FUEL FABRICATION PLANT

2.1 Major Activities

The major activity of the LWR fuel fabrication plant is to produce MOX pellets, rods, and fuel assemblies, according to applicable standards and regulations. Auxiliary processes such as wet scrap reprocessing and waste treatment are also included to minimize environmental impact and to close accountability.

This fuel fabrication plant is considered a "stand alone" type plant in that feed powder will be received and completed fuel bundles will be shipped. Contaminated scrap will be reprocessed internally and low level waste will be concentrated and packaged for disposal offsite. The plant design includes only those functions necessary to support fuel fabrication. The administration building, guard house, and utility buildings are not included, nor are site preparation, water, electricity and sewer services.

The simplified process flow associated with the described MOX fuel fabrication plant is shown in Figure 1.

2.2 Plant Capacity

It is assumed that the MOX fabrication plant will have an effective capacity of 200 metric tonnes of heavy metal (MTHM) per year contained in finished fuel assemblies. Considering an on-line efficienty factor of 66 percent, the minimum design capacity is 300 MTHM per year. Assumptions used to

FUEL FABRICATION PLANT

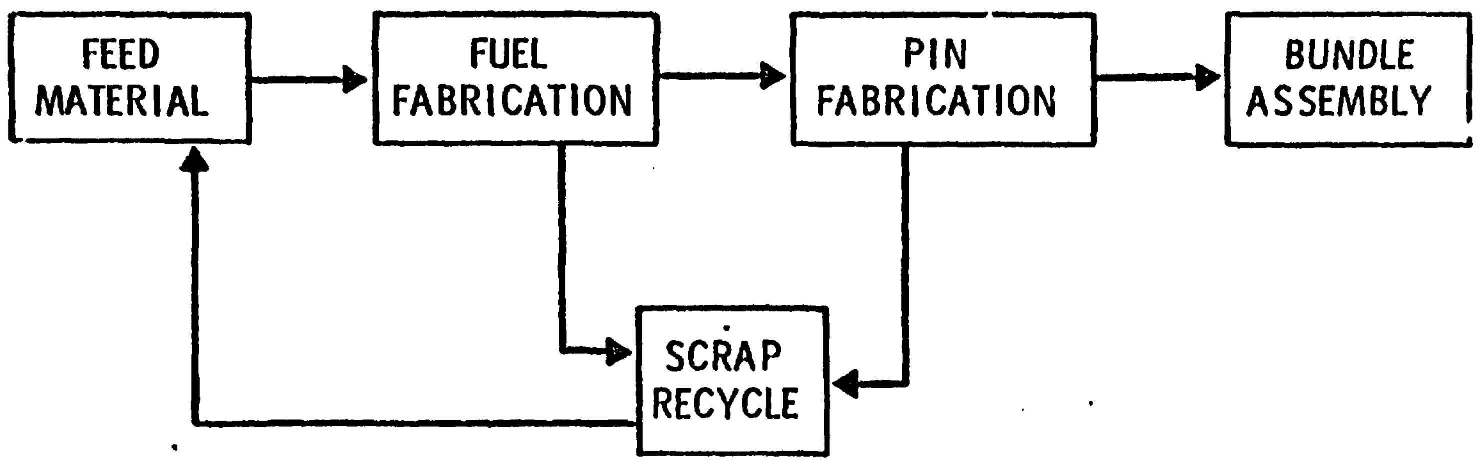


FIGURE 1
GENERAL PROCESS FLOW

establish a plant efficiency factor include: 250 working days per year, two shifts per day, fuel enrichment changes (approximately 3 per core), equipment repair down time, and accountability inventory down time. To achieve 200 MTHM per year, about 10 MT Pu must be processed at an average enrichment of 4.5% Pu. The Process described allows for about 10 to 15% reject product which will be recycled.

2.3 Operation Philosophy

The fuel fabrication lines will be operated in a campaign mode. Recognizing that different Pu enrichment will be required for different reloads, reloads having the same enrichment will be grouped into the same campaign as often as possible. Two separate lines each having an effective capacity of 100 MTHM allows two enrichments to be processed simultaneously. A campaign would produce a nominal 10 MTHM of fuel in a nominal 16 days which includes a 3 day allowance for cleanout.

3.0 FABRICATION PROCESS

The process flowsheet for fabricating LWR MOX fuel assemblies is presented in Figure 2. Clean scrap is recycled directly for powders, or through a simple oxidation - reduction and comminution process for pellets. Dirty scrap is chemically cleaned and co-processed to provide sinterable feed. Waste and trash are treated, assayed, and packaged prior to disposal.

3.1 Product Manufacture

The fuel process described is based on current mixed oxide fuel fabrication technology, at reasonable production levels which provides for efficient operation.

3.1.1 Mixed Oxide Fuel Fabrication Process

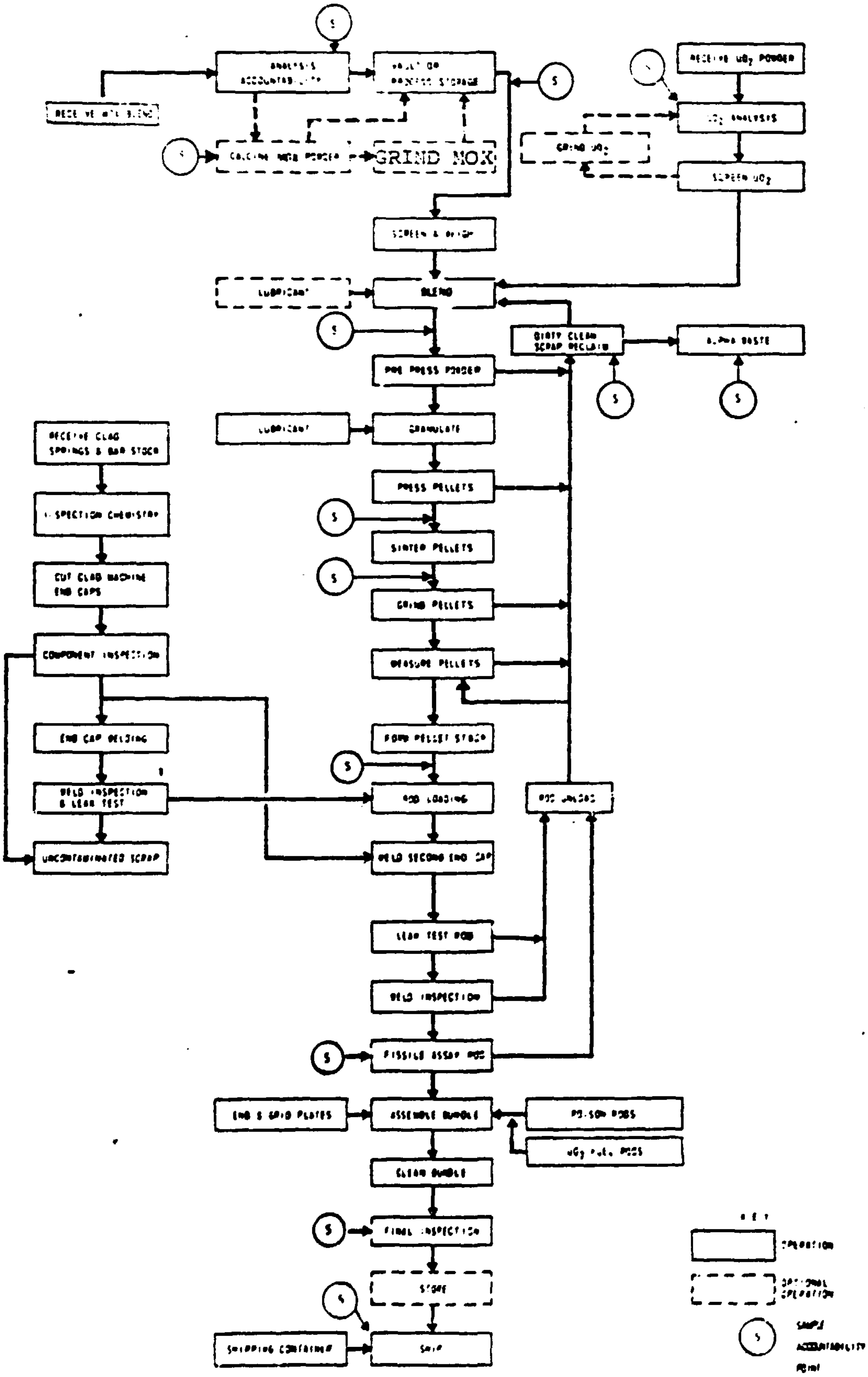


Figure 2

FUEL FABRICATION PROCESS FLOW SHEET (U, Pu)O_2

3.1.1.1 Pelletization and Pin Loading

The primary functions of the receiving station are to receive, weigh, and distribute SNM to and from the process lines. Equipment provided in this station includes a fully automated internal SNM handling system and accountability equipment. The receiving station equipment is sized to handle the production requirements of the fabrication line plus expected waste and SNM (other than pins) leaving line containment. The data collection system will also record UO_2 characteristics and ^{235}U content for batching control.

Powders are proportionally batched, blended, and milied to provide properly-conditioned mixed-oxide powder to the prepress operation. The batching system consists of a transfer system, feed and control mechanisms, in-process material containers, and a computer/processor batching control system. A computer analyzes data from the characterized raw materials, formulates the proper constituent percentages, analyzes feedback from close-coupled analysis, and controls the transfer system rate to deliver powder to the blending/milling operation.

The pressing operation is embodied in three primary steps. The first step contains a prepressing operation with pre-pressed pellets fed directly into the second (granulation) step to produce feed for final pressing. A binder/lubricant addition and blending operation is also contained in the second step. A third step contains equipment for high-speed pellet pressing, green density measurements, sintering boat loading, and a boat transfer system. Scrap pellets would be returned to the granulation step for recycle.

The sintering operation includes boat storage, furnace loading, a continuous sintering furnace, boat unloading and storage, a boat return system to the pellet press, and a pellet sampler for analytical chemistry.

The boat load and unload system must provide at least a 48-hour storage capacity for the continuously operating sintering furnace. Atmosphere control is necessary on each side of the furnace to maintain a consistent atmosphere in the furnace enclosure. The boat storage is in a geometrically critically safe array. Boats are automatically loaded into the sintering furnace. The furnace progressively debinds green pellets from the pressing operation, sinters pellets at 1600^0 - 1800^0C, and cools them to approximately room temperature. Pellet properties and sintering dynamics are maintained by feedback from the process control center receiving real-time information from close--coupled analysis. After sintering, a sampling device randomly selects pellets from each boat and transfers those pellets to gaging and/or an off-line operation for analysis.

The pellet gage inspects pellets for length, diameter, mass, and surface flaws at a rate of about three per second. Pellet weight information is used as an accountability check. The gage is also equipped with special sensors to detect defective pellets. Nonconforming pellets are segregated and transported to off-line storage for subsequent recycle. Acceptable pellets are transferred to the pin load/weld station.

Pellet storage provides in-process storage for acceptable pellets prior to pin loading and reject pellets that may require grinding, moisture adjustment, or outgas. Scrap pellets to be sent to an oxidation-reduction or grinding operation will also be stored. The storage area will accommodate at least 2 days production from the sintering furnace.

An outgassing operation drives off internal pellet gases by heating the pellets under vacuum. Furnace loading, sealing, opening, and unloading is automated.

Sintered pellets will be centerless ground to maintain the necessary diametral tolerances.

The cladding tubes make up the primary containment after loading. All fuel pin components will be assembled into the cladding, the fuel and upper components will then be loaded, the cladding ends automatically decontaminated, the upper end caps welded, and the welds helium leak-checked. The system would be controlled by a minicomputer to monitor the processes, confirm proper operation sequence, and identify any malfunction.

3.1.1.2 Fabrication Line Mechanical Area

The combined purpose of the pin finishing and inspection operation is to inspect, clean, and deliver fuel pins to the bundle assembly area. Primary containment is provided by fuel cladding.

After the pin load/weld operation, pins will move to an ultrasonic weld inspection station. Pins are automatically segregated into acceptable and reject categories. Acceptable pins are transported to the fissile assay station. Reject pins are collected for rework or unloading.

A fissile assay station will check percent ^{239}Pu, total fissile content, and relative time since Pu separation (powder lot confirmation) for every pellet in each pin. The accumulation of pellet data will provide a measure of lot homogeneity, average percent ^{239}Pu, and total grams fissile for each pin.

Radiography will normally be an off-line operation. Its primary purpose is to evaluate anomalies detected during the gamma scan at the fissile assay station (i.e., check stack length, component placement, and flaws).

The surface inspection station will employ a pattern-recognition laser scanning system to inspect fuel pins for surface flaws. Pin diameter will be determined using electro-optics and photodiode arrays. After inspection, acceptable pins are transferred to the pin storage enclosure and reject pins collected for reprocessing.

3.1.1.3 In-Process Inventory Requirements

A manufacturing process will require feed powder, process line buffer, finished fuel pin and completed assembly storage in addition to dry and wet scrap accumulation points. Table 1 presents estimated In-Process Stgorage Requirements. For normal operation a 200 MTHM/yr. plant must maintain an average product throughput of 800 kg/day based on 250 working days/yr.

3.2 Scrap and Waste Processing

3.2.1 Clean Scrap Recycle

Oxidation-reduction or grinding will be used to convert nonconforming pellets or powders to acceptable material. Some material, such as powder or granules at the pressing station, may be recycled through the same unit operation.

3.2.2 Dirty Scrap Recycle

The scrap recycle system receives unacceptable fuel materials from the fabrication operation and processes it to produce a mixed plutonium-uranium nitrate solution which is converted by coprecipitation to powder for recycle. Processing operations used to recycle the dirty scrap include dissolution, solvent extraction, recovery and purification, and nitrate conversions. Small quantities of plutonium rich material, such as undissolved residue and some analytical samples, are dissolved in a separate operation where fluorides are used. The cleaned scrap is then recycled back into the fabrication line as a powder.

3.2.3 Waste Handling

All liquid effluent from the fuel fabrication plant is monitored for radioactivity. Sanitary liquid waste is monitored and disposed of through the plant sewage system. All other non-radioactive liquid waste is released to the process sewer system. Radioactive liquid wastes are collected, processed and disposed of in concrete.

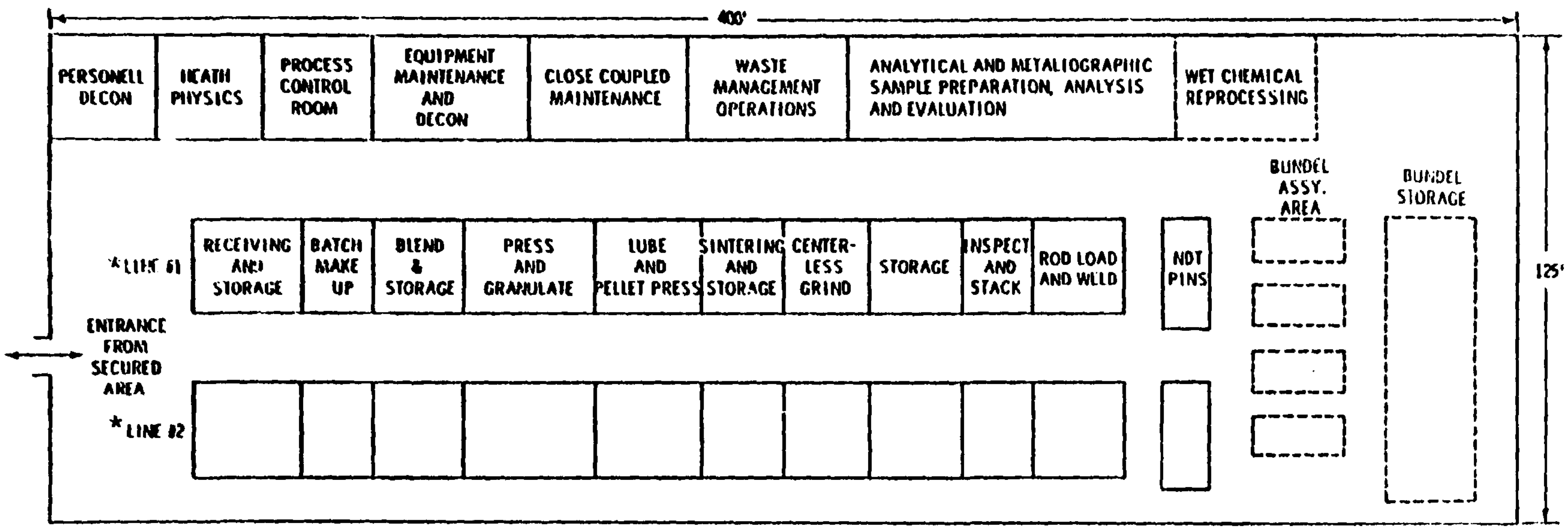
TABLE 1

PROCESS LINE STORAGE REQUIREMENTS

Storage Location	Material Form	Process Capacity	Fissile* Inventory
Feed Receiving	MOX Powder	Two months	2 M.T.
Line Buffer			
-Green Pellet	MOX Compacts	2 days	50 Kg
-Sintered Pellet	MOX Sintered Pellets	2 days	50 Kg
Finished Pin	Pellets in Pins	2 days (9200 Pins)	80 Kg
Fuel Bundle	Pellets in Pins	Two Core Reloads	1 MT
Dry Scrap	MOX Powder, Pellets	1 week	20 Kg
Wet Scrap	Contaminated MOX Powder, Clad, etc.	2 weeks	13 Kg

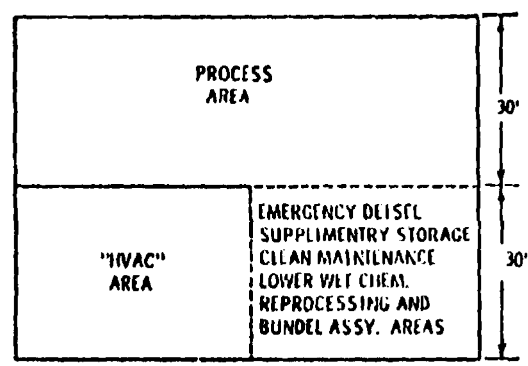
*Based on 4.5% nominal (U, Pu) content

CONCEPTUAL LWR – MOX FUEL FABRICATION FACILITY



PROCESS FLOOR DETAIL

*NOTE: Partitions to aid contamination control between compatible groups of unit operations are not shown.



BUILDING END VIEW

Figure 2

Solid non-radioactive waste is consolidated and disposed of in burial grounds. Solid radioactive waste is collected, processed and stored for future disposal.

4.0 PLANT GENERAL LAY-OUT AND DESCRIPTION

4.1 General Lay-Out

The general lay-out of this fuel fabrication facility is shown in Figure 3. Two process lines are shown with unit operation sequence identified. Line partitions are not intended to reflect actual space requirements. The dotted lines on the process floor and in the end view represent pit or "high bay" region.

4.2 General Description

4.2.1 Fuel Building Structural Design

The Fuel Building is a reinforced concrete shear-wall structure. The building structure is classified as a critical structure and therefore must withstand design basis accidents (such as design basis fire and explosion) and natural phenomena (including the design basis earthquake and tornado) and continue to provide containment for the potentially contaminated building atmosphere.

In addition to structural requirements, the walls, floor, and ceilings of the SNM storage area, fuel pin storage area, process cell, and external walls are designed to provide radiation shielding using normal density concrete of 150 lb/cu ft (2400 kg/m^3).

4.2.2 Fuel Building Configuration

The first floor contains most process operations and the basement contains HVAC (Heating, Ventilation, and Air Conditioning), utility, and electrical equipment. Piping and electrical utility connections are routed through the basement. Distribution to the process area is provided through the utility corridor. A system of wall penetrations in the utility corridor allows the utility piping to be routed overhead and dropped down to the first floor equipment.

The Fabrication Line Control Room, Close-Coupled Analysis Control Room, Wet Scrap Control Room, and an observation corridor overlooking the Fabrication Line Mechanical Assembly and Fuel Fabrication areas are located on the mezzanine above the process floor.

4.2.3 Fuel Building-First Floor

The Fuel Building first floor is divided into several areas including the Mechanical Area (high-bay), Assembly Area, Fuel Fabrication Area, Special Nuclear Material (SNM) Assay and Close-Coupled Analysis Laboratories, and the Wet Scrap Area (high-bay).

Normal access to the Fuel Building is through personnel and equipment air locks located adjacent to and controlled from the guard station in the Support Building (not shown). Primary access to the process areas is provided by the main corridor. Secondary corridors connect the main corridor to the Support Building and provide access to the SNM Receiving and Assay Areas.

SNM is received at a secured enclosed loading dock. The sealed canisters containing the SNM materials are removed form the shipping containers, analyzed, and identified in the Assay Area and transferred to the SNM Storage Area in the basement for indexed storage. Storage and retrieval are accomplished through automated lift stations and computer controlled storage/-retrieval machines. Lift stations into the SNM Storage Area are located in the SNM Receiving and Assay Areas, in the powder preparation section of the fabrication line, and in the Cask Handling Area.

An assembly storage area with storage locations for pins or fuel assemblies is located in the high-bay area. Fuel assemblies will be handled with a high-bay bridge crane. Completed assemblies are stored in vertical stainless-steel lined rectangular concrete ports that are located in the basement.

4.2.4 Fuel Building Basement

The basement contains space for mechanical equipment and control systems that provide the utility services for the Fuel Building. The equipment includes HVAC plenums, electrical distribution transformers and switchgear, and various tankage and piping.

The Facility Control Room is located on the basement mezzanine with accessibility to an outside emergency exit. It is physically isolated from the rest of the basement and has a separate ventilation system. Personnel access to the basement is normally form the Support Building past the guard station and down flights of stairs. Vehicle and equipment access to the mechanical area is provided by a ramp down to an exterior door. This door is normally locked and may be opened only by a security guard who will remain in attendance while the door is unlocked. Emergency air locks are strategically located. Openings in the Fuel Building shell are protected by missile barriers, except the basement equipment entry which has a tornado-missile resistant door.

Process and utilities drains are provided throughout the Fuel Building. Two drain systems are located in the basement: the Hot Drain Retention System and the Liquid Effluent System. Both drain systems are equipped with necessary piping, instrumentation, monitoring equipment, and sampling stations to monitor the discharged effluent. shielded slab tanks are provided in the basement for collection of radioactive liquid waste. A low-level radioactive waste collection system for solid wastes is also provided in the basement.

4.2.5 Storage of Special Nuclear Material

The shielded SNM storage area is located in the basement. Canisters are stored in pallets on racks along the side walls of the storage area. Each pallet can contain up to six canisters. Racks and pallets are designed to withstand the design basis accident without spilling or dislodging the canisters. Automated computer-controlled storage/retrieval (S/R) machines pick up pallets from the storage rack and transport them to the desired lift station. The pallets are transferred to the lift station and raised into the lift station enclosures.

The S/R is equipped with its own flood lights and closed circuit TV system mounted on the moving lift. This operation is isolated from operating personnel. The S/R maintenance areas are located at the outer ends of each storage area and are designed to provide a normal working environment for maintenance activities. Personnel protection from radiation during maintenance on the S/R is provided by shielded doors located between the storage and maintenance areas. Access to the maintenance and storage areas is through security doors.

4.2.6 Support Building

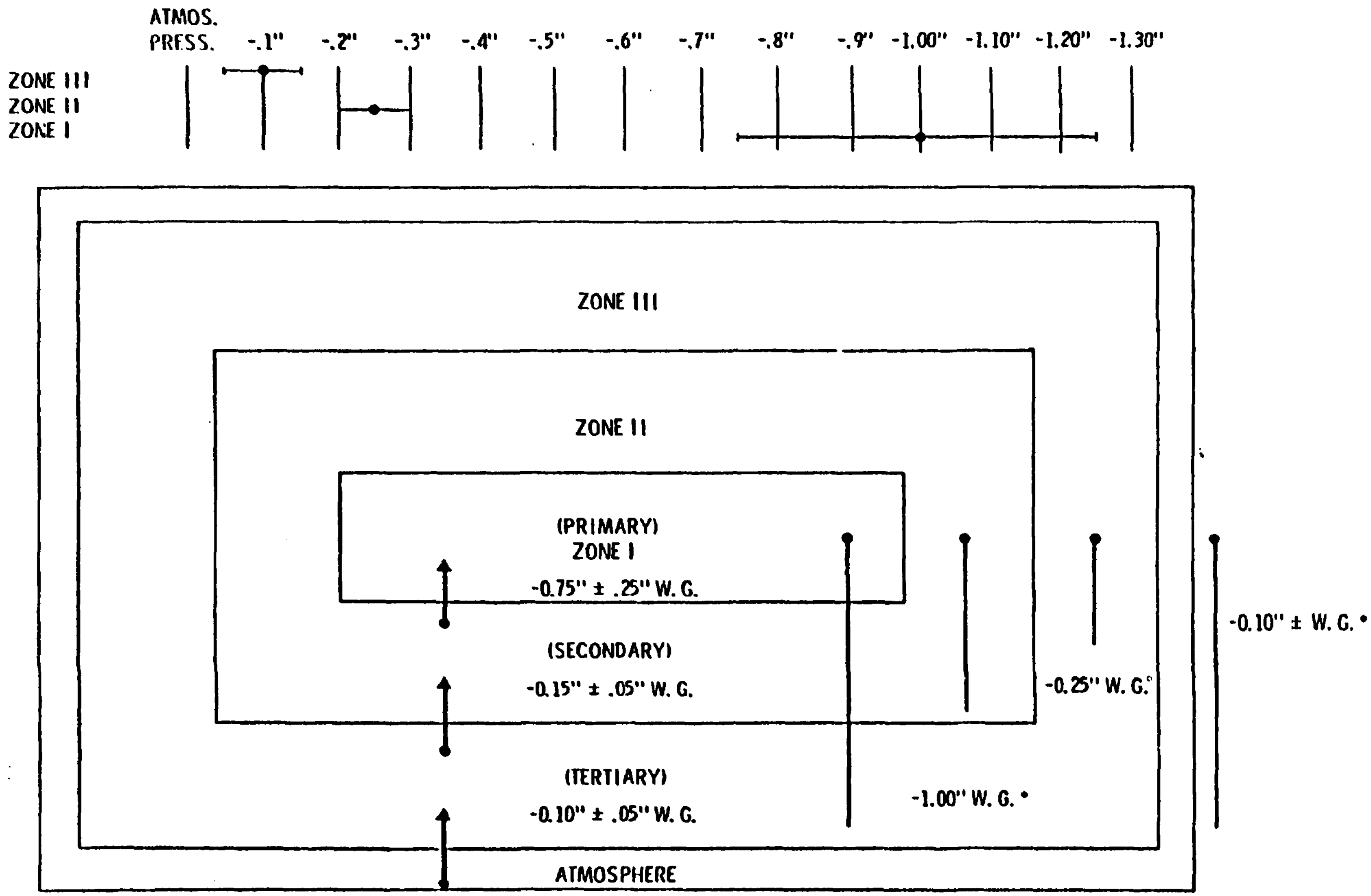
Although these buildings are required to support the fuel fabrication facility, for the purpose of this report these buildings and services will not be shown or costed. Section 6.6 of this report addresses some security/safeguards aspects of these support buildings.

- Administration Building
- Guard House and Associated Office
- Sanitary Sewer and Treatment Facility
- Water Supply and Cooling Tower
- Garage for Fire Fighting Equipment and Maintenance
- General Receiving and Stores

5.0 PLUTONIUM CONFINEMENTS AND VENTILATING SYSTEM

5.1 Confinement Zones

Confinement zones are assigned according to the levels of potential radioactive contamination. Pressure differentials between access zones are designed so that air flow is from lower radiation contamination potential to high radiaition contamination potential (Figure 4). The HVAC system is designed to control air flow within the zones of differing values of potential radioactive contamination.



*W. G. = WATER GAUGE DIFFERENTIAL PRESSURE

FIGURE 4 VENTILATION AND CONFINEMENT ZONES

Zones are classified as follows:

Zone I (Primary) areas include the process enclosures and other spaces that contain radioactive materials during normal or abnormal plant operation. This zone is considered to have the highest radioactive contamination potential and is maintained at maximum negative pressure relative to the atmosphere. If a Zone I enclosure is breached, confinement depends upon air flow from the surrounding space through the breach.

Zone II (Secondary) areas include those areas which may become contaminated if the Zone I confinement is breached. This would include such areas as chemistry laboratories, equipment operating and control areas, etc.

Zone III (Tertiary) areas are the areas of least contamination and would include office areas, health and safety offices, security, etc. The ventilation system is designed to provide clean, filtered, outside air into the Zone I area. The exhaust air from Zone I is conditioned and recirculated into Zone II. Make-up air necessary to maintain the desired pressure differential is taken from the outside. Subsequently, Zone II air is taken into the Zone II area as needed. Again, any make-up air will be taken in from the outside. The air exhausted from Zones I and II will pass through four banks of absolute filters prior to being discharged to the atmosphere. Fire protection and safety systems are built into the ventilation system to withstand a design basis accident. To assist in the containment of radioactive contamination the process area will contain partitions enclosing compatible unit operations. Should an accidential release occur only a portion of a line would be affected and clean-up, repair, or modification operations could proceed concurrently with continued production in the non-affected portions of the line.

6.0 PROTECTION MEASURES

6.1 Protection Against Criticality

Plant process equipment that can accumulate fissile materials are designed and operated to prevent critical incidents. The primary design variables addressed to prevent any critical incident for the materials to be processed in the facility are:

- Mass of fissionable material
- Shape (geometry)
- Reflection
- Volume
- Interaction
- Components present
- Concentration of fissionable material
- Poisons

6.2 Dosimetry

The MOX fuel fabrication facility is designed and operated in a manner to assure that personnel are not exposed to α, β, γ, and n radiation in excess of low as practical levels. The α, β, and γ radiation are detected using continuous air monitors (CAM) and scheduled smear tests. Additionally, instrumentation is provided to detect abnormally high γ and n activity.

Personal dosimetry is monitored using film badges and Thermo-Luminescence Dosimeters (TLD) for gamma radiation and pencil badges for neutron exposure. Additionally, ionization monitors are located at entrance and exit areas in addition to hand held units at particular work stations.

6.3 Safety Analysis and Environmental Impact

6.3.1 Radiation and Effluent Monitoring

The primary objective of the radiological protection program is to provide confidence that the external radiation exposures to the public and internal radiation exposures to plant personnel, including anticipated operational occurrences, from postulated accidents will be kept as low as practicable and within applicable limits.

Operational personnel radiation exposures are controlled by the facility design and monitored by the air monitoring and contamination control programs and are designed to maintain exposure levels to less than 0.25 mr/hr.

6.3.2 Plant Monitoring System

The radiation monitoring system is in conjunction with the in-plant sampling program and is designed to monitor and record radiation levels in all plant effluents and to isolate effluent streams containing radioactivity when activity levels reach a preset limit. This system operates continuously and is tested at prescribed intervals.

6.3.3 Radiation Dose Rates

The shielding design objective is specified to reduce the external dose rates to 0.4 mr/hr in the Normal Access Area or Tests wherever practical.

The combination of the ventilation system and the physical confinement barriers normally maintains airborne radioactivity levels in the Normal and Limited Access Areas to levels estimated to be less than an internal radiation dose of 0.4 mr/hr.

6.3.4 Airborne Radioactivity Monitoring Program

The air monitoring system is in accordance with ANS N13.1, "Guide to Sampling Airborne Systems in Nuclear Facilities." The in-plant air monitoring program consists of these types of air sampling:

- Fixed work-place air sampling stations
- Portable air samplers
- Continuous air monitors with recorders and alarms

Portable air samplers are used to supplement the station samplers for special evaluations, surveys, and during non-routine-type operations. Portable-type air samplers are available for taking samples for prompt evaluation. Two sets of continuous air monitors (alpha, beta, and gamma) are located to provide an alarm and visual indication and/or to record the levels in a control zone and to monitor overall and specific HVAC operations.

6.3.5 Effluent Gas Monitoring System

There is a coninuous iso-kinetic air monitor for alpha particulates installed in the exhaust vent which will record continuously and annunciate abnormal radioactivity by an alarm. Air samples also will be collected from the exhaust system. Since the ^{239}Pu background concentration expected from U.S. Public Health Service data is in the order of 10^{-5} pCi/m^3, a sample volume in excess of 200 m^3 must be collected in order to achieve a minimum sensitivity sample of 0.02 pCi. Accordingly, the sampler will be designed to achieve a flow rate of approximately 2 cfm.

The efficiencies for the filters taken individually are 99.763 percent for the first, 92.95 percent for the second, and 90.13 percent for the third for the particle size distribution as seen by each filter in series. Based on these numbers, for those safety evaluations where all three stages of high efficiency filtration are intact, the efficiency is conservatively taken as 99.995 percent, and in those situations where only the final filtration stages are present, the efficiency is conservatively taken as 99.95 percent.

6.4 Building Safety

6.4.1 Fire Protection, General

The fire protection system for the Fuel Building is provided to detect, contain, and suppress fires. Alarm systems are designed to provide prompt notification to operating, fire protection, and security forces so that timely and appropriate action can be taken to protect personnel and property, to mitigate damage from fire, smoke, and water, and to contain those fires which may not be controlled and limited if the automatic suppression systems fail to function.

The Fuel Building will have an overall fire rating of two hours minimum and will remain standing as a containment structure during and after the maximum anticipated (design basis) fire within the structure, assuming complete loss of fire suppression systems. The exterior walls have a minimum fire resistance rating of four hours and interior walls one hour. The roof has a two-hour rating. Fire doors are sliding, rolling, or hinged-type with automatic closing and latching provisions. Each rated door will have approval for the appropriate service fire rating.

6.4.2 Design Features

Facility design uses components of fire-resistant and non-combustible material wherever possible, particularly in corridors, containment barriers, and structural members including walls, partitions, columns, beams, floor, and roofs. A local-energy fire alarm system is provided to give early warning of fire by detecting heat or products of combustion. Sensors are installed throughout the Fuel Building at strategic locations, including inside process enclosures at major electrical components and in essential parts of the ventilation system.

The facility "fire loading", as presently conceived, is low in available combustibles. The present concept has a loading less than 53,000 kilocalories per square meter of floor space. The building is protected by an engineered fire sprinkler system. The sprinkler system in the laboratory areas incorporates wetpipe, ordinary hazard sprinklers. A separate sprinkler system is provided for the Zones I and II Filter Plenum Exhaust Systems. These are supplied by a dedicated water supply hardened against natural phenomena and are not dependent on the yard supply. Water for sprinkler systems, standpipes, and hydrants is supplied by an electric-driven fire pump in the Pump House through a 25 cm diameter fire loop.

6.4.3 Ventilation

The ventilation systems for Zone I are capable of operating during a fire. A multiple zone return arrangement consisting of groups of rooms connected to the recirculating fans facilitates zone exhaust for smoke removal. Smoke removal exhaust is accomplished through multiple damper actuations to divert smoke-laden air through the Zone II final exhaust filtration system. In this operation, the zone return fan will be shut off and bypassed by the room smoke detector which will simultaneously energize the final exhaust system at maximum capacity if required.

7.0 ORGANIZATION OF PLANT

Management

The facility manager has the overall responsiblity for the safe and effective use of the Pu fuel fabrication facility. The manager of operations is responsible for the safe operation of the fuel fabrication facility.

Quality Assurance

The manager of quality assurance is responsible to assure that all processing, training, completed product, inspection, audits and calibration/-maintenance is performed to meet requirements of the quality control manual.

Administration Control

Prepare operational and administrative documents which establish formal programs to assure compliance with applicable regulations. Instructions and procedures will be prepared to translate the general requirements into specific guidelines and limits to be followed by the operating staff.

Personnel

Established training programs for the personnel is manditory, but the operating personnel are required additional training in any position of the operation in which they are associated. As a minimum, all personnel must attend training programs in these areas:

- Criticality safety
- Radiation protection
- Building emergency procedures
- Industrial Safety
- Job layouts
- Security

Table 2 shows a general breakdown of the facility organization. It should be noted that the organization provides the structure necessary to assure the independence of organizations for the control of quality and safety required by the quality assurance program.

8.0 STATUS OF TECHNOLOGY

Development quantities of LWR MOX fuel have been fabricated in both national laboratories and commercial facilities. These facilities are basically glovebox type operations and do not reflect the processing equipment technology required for a large capacity plant. Although the basic processes may be used, considerable development is required to automate and integrate equipment into an automated system. Development work is necessary to establish reliable materials handling systems. Throughout the plant surge type inventory is necessary and technology for placing and extracting material of various forms from inventory storage is required. Additionally, biological shielding techniques must be developed which will enable personnel to operate, and perform hands-on-type equipment maintenance.

These areas of technology development have been investigated by both the commercial industry and government laboratories, however, in only a few cases has the development progressed to a hot demonstration stage. The information in Table 3 is a brief summary of the development status and requirements for LWR MOX fuel.

PLANT MANAGER

perations

Gen. Foreman
- Foreman
- Foreman
- Foreman

Works Engineer
- Maint. Foreman
- Maint. Foreman

Production Manager

Engineering

- Process Eng. Supv.
- Fuel Eng. Supv.
- Pin and Bundle Supv.

Quality Assurance

- Lab Supervisor
- Process Control Supv.
- Records Supv.
- Audit Supv.

Administration

- Security
- Purch/Stores
- Controller
- Adm. Serv.
- Accountability
- Health Physics

In either case, MOX or spiked facility, the total personnel will be the same, but the mix of technicians and others would change.

LWR-MOX FULE FABRICATION FACILITY ORGANIZATION

TABLE 2

TABLE 3

DEVELOPMENT REQUIREMENTS FOR AUTOMATED FUEL FABRICATION PLANTS

UNIT OPERATION	CURRENT STATUS	MOX REQUIREMENTS	DEVELOPMENT STATUS
MOX Receiving	Manual Transfer and Accountability	Mechanized Transfer, Accountability, and Reseal	Cold Laboratory
Feed Powder Modification	Manual Load and Unload	Dust Control, Improved Accountability	Cold Laboratory
Slug and Pellet Compaction	Automated Pressing	Dust Control, Improved Accountability, Transfer Systems Interfaces	Hot Engineering
Sintering	Batch and Automatic Furnaces	Mechanized Loading and Unloading, Accountability Interface	Hot Laboratory
Grinding and Measuring	High Dust	Dust Control, Auto Transfer, Accountability Interface	Hot Laboratory
Pin Fabrication	Manual Load, Decon, and Welding	Mechanized Load, Decon, and Welding	Cold Laboratory
NDA Exam	Manual Transfer to Stations	Mechanized Transfer, and Exam	Cold Laboratory
Bundle Assembly	Manual Assembly and Inspection	Mechanized Assembly, Bundle Redesign	Cold Laboratory
Overall Transfer System	Manual Transfer	Mechanized with Accountability Stations	Cold Laboratory

ADDENDUM TO MOX FUEL FABRICATION FACILITY SPIKED COPROCESSED FEED, PELLETIZED FUEL

1.0 INTRODUCTION

Recently, the use of Alternative Nuclear Fuel concepts have become of greater interest because of the increased concern over the feasibility of diversion of fissile materials for making nuclear explosives. A plant designed to process spiked mixed oxide feed material is considered here. The material is assumed to be ^{60}Co at a concentration to deliver 1000 R/hr at 1 m.

The addition of a spikant will not change the basic fabrication process, however, significant plant size changes are required to accommodate the remote fabrication and maintenance operating mode. Additionally, plant operating and capital costs will be higher due to the increased shielding and the remote operation mode.

2.0 DEFINITION OF THE SPIKED FUEL FABRICATION FACILITY

The major activities, plant capacity, operating philosophy and in-process inventory requirements would be the same for a spiked, mixed oxide facility as described under section 2.0 of the main report.

3.0 FABRICATION PROCESSES

The addition of a spikant will not change the fabrication process as such. Development costs must increase to provide the increased reliability and design innovation necessary to accommodate fully automated remote processing and maintenance. Spiking of the fuel will require some changes in the waste management area of the plant, but these will not have a major impact on the waste products from the plant. Additional shielding, manipulator costs, and material transfer equipment requirements will increase overall plant costs.

4.0 PLANT GENERAL LAY-OUT AND DESCRIPTION

The fact that spiked fuel requires cell operation does result in fundamental differences in plant layout. Figure 5 shows a layout of a spiked fuel fabrication facility. The process equipment as well as the maintenance area is all surrounded with 4 1/2 ft. of standard density concrete for biological shielding. Analytical chemistry facilities also require biological shielding of about 2 feet thickness. This decrease is due to the lower mass of fuel material in process. This additional shielding results in an overall larger size plant to accommodate the same equipment. (See Section 6)

The main building design is based on the concept of heavily shielded process cells with surrounding areas for control rooms, analytical laboratory, wiring and piping areas, change rooms, etc.; all to be surrounded by an external building shell capable of withstanding naturally occurring and man-made design base accidents. In the design, most of the control mechanisms and all of the personnel are outside the heavily shielded containment canyons. In the event of an accident, it must be possible to bring the plant to a safe shutdown. Thus controls, emergency facilities, and personnel must be physical protected against accidents. Therefore, the outer shell of the process building (including the emergency power supply) must withstand design accident conditins. The shell provides the final containment of radioactive material with the canyon construction providing secondary containment.

Primary containment is in the process equipment. The processing of spiked mixed oxide fuel will require the use of manipulators and remotely controlled equipment for normal and emergency maintenance. The maintenance function is a principal consideration in the operation of a remote and automated plant.

Accountability systems having acceptable accuracy and precision are assumed. However, considerable development work is necessary to develop systems which have the sensitivity within the high gamma field resulting from the spikant.

Radiation monitoring will be extensive, however, the primary deterrent to exposure will be the biological shielding. Environmental monitoring will be similar to that in reactor and separation plants.

5.0 PLUTONIUM CONFINEMENT AND VENTILATION SYSTEMS

The plutonium confinement and ventilation systems will be the same as those described in section 5 of the main report. The size of the ventilation system would be increased to meet the larger plant size required for the spiked fuel facility.

6.0 PROTECTION MEASURES

6.1 Protection Against Criticality

Equipment, transfer systems, and storage areas are designed to prevent critical incidents. Philosophy and guidelines are the same as those mentioned in section 6.1 of the main report.

6.2 Dosimetry Criteria

The capability to develop fabrication processes for proliferation resistant alternate fuels must be provided in a manner which assures personnel exposure limits will not be exceeded. Spiked or high activity fuels such as those resulting from low decontamination (low DF) or from the addition of high activity isotopes (spikants), or combinations of those will be processed.

Process equipment and lines will be designed to minimize operating personnel and minimize capital cost. Material level, energy spectra, and distribution (geometry, location and concentration) will be used to establish exact shielding requirements at key locations. Requirements cannot be overly conservative as they could impose a major facility cost penalty.

Analysis

Assumptions made to provide calculation base are:

- Source Strength

  1000 R/hr at 1 meter as ^{60}Co

- Exposure Limit

The combined neutron and gamma level will be less than 0.2 mR/hr in occupied areas which is lower than that allowed in the unspiked facility for process line environmental considerations.

Shielding of 4.5 feet of 147 #/ft^3 concrete or 3-1/2 feet of 200 #/ft^3 concrete will meet requirements with a reasonable degree of conservatism. In areas which source strength is smaller, such as in analytical chemistry support area, shielding thickness may be reduced.

7.0 ORGANIZATION OF THE PLANT

The organization is the same as that described in Section 7 of the main report.

8.0 STATUS OF TECHNOLOGY

In this plant all operations and maintenance will be accomplished in a remote mode. Remote operation and maintenance will dictate the development of special processes and interfacing equipment. In addition, the high gamma activity of the spiked fuel imposes additional criteria on the serviceability of materials used equipment construction and operation. It is not known what effect the spikant may have on the sintering characteristics of the fuel. However, it is assumed the spikant will be a compatible ceramic refractory oxide. The information in Table 4 is a brief summary of the development status and requirements for spiked LWR-MOX Fuel Fabrication.

TABLE 4

DEVELOPMENT REQUIREMENTS FOR AUTOMATED, REMOTELY MAINTAINED FABRICATION PLANTS

UNIT OPERATION	CURRENT STATUS	SPIKED MOX REQUIREMENTS	DEVELOPMENT STATUS
MOX Receiving	Manual Transfer and Accountability	Automated Transfer, Accountability, and Reseal	Cold Laboratory
Feed Powder Modification	Manual Load and Unload	Dust Control, Auto Transfer, and Accountability Interface	Cold Laboratory
Slug and Pellet Campaction	Automated Pressing	Dust Control, Auto Transfer, Auto Clean Recycle	Hot Engineering
Sintering	Batch and Automatic Furnaces	Auto Load and Unload, Furnace Redesign for Maintenance	Hot Laboratory
Grinding and Measuring	High Dust	Dust Control, Auto Transfer, Accountability Interface	Hot Laboratory
Pin Fabrication	Manual Load, Decon, and Welding	Auto Load, Decon, and Weld	Cold Laboratory
NDA Exam	Manual Transfer to Stations	Auto Transfer, New NDA Methods Development	Cold Laboratory
Bundle Assembly	Manual Assembly and Inspection	Mechanized Assembly, Extensive Bundle Redesign Needed	Cold Laboratory
Overall Transfer System	Manual Transfer	Auto Transfer, High Reliability, Easy Maintenance, Accountability Interface	Cold Laboratory