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SECURE AUTOMATED FABRICATION:
A SYSTEM DESIGN DESCRIPTION (SDD), SECTION 1

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FUNCTION 1

CONVERSION

SYSTEM DESIGN DESCRIPTION, SECTION 1

CONVERSION

SYSTEM DESIGN DESCRIPTION, SECTION 1

This section contains the specific functions, criteria and design requirements necessary for the conceptual design of a conversion system to convert purified mixed nitrate solution to MO_x powder. This system will support a 150 MTHM/year mixed oxide fuel fabrication facility.

RDT Standard F1-2T, "Preparation of System Design Descriptions", dated September, 1975, was used as the basis for preparation of the System Design Description (SDD).

1.0 Functions

1.1 General

- o The requirements established in the Secure Automated Fabrication (SAF) analysis (product, process and SAF requirements) shall be met as part of this design.
- o The design shall incorporate fully remote operation. Some contact maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Support functions are assumed to be provided as necessary.
- o Each station shall be capable of operation in an automatic mode but shall be equipped with manual over-ride capabilities for non-steady state operations.
- o Powder transfers between stations and/or storage are assumed to occur by some given method and are not considered as part of this SDD.
- o Each station shall be provided with the capability of performing the SNM transactions necessary to meet accountability requirements.

1.2 Conversion

1.2.1 Make Up Feed

- o Receive U-Pu nitrate solution
- o Mix the solution to the appropriate ratio

- o Measure the solution volume, temperature and density
- o Analyze the solution

1.2.2 Coprecipitate U and Pu

- o Meter mixed nitrate and NH_4OH to the precipitator at a controlled rate while continuously monitoring pH of the precipitator
- o Precipitate U and Pu in the continuously stirred precipitator
- o Transfer the slurry to the calciner

1.2.3 Calcine Precipitate

- o Set and control the operating temperature and nitrogen gas flows to the calciner
- o Feed the slurry into the operating calciner
- o Calcine the slurry to MO_x powder
- o Separate offgas from the powder and remove the offgas for processing
- o Break up powder agglomerates
- o Separate the calciner shot from the powder, recycling the collected shot to the calciner
- o Collect the MO_x powder and transfer it to the reduction stabilization furnace

1.2.4 Reduce and Stabilize Powder

- o Set and control the temperature, time cycle and argon hydrogen flows to the reduction furnace
- o Reduce the MO_x to MO_2
- o Separate the offgas from the powder

- o Set and control the temperature, time cycle and carbon dioxide flows to the stabilization furnace
- o Stabilize the powder by controlled oxidation
- o Separate the offgas from the powder
- o Blend the powder into batches
- o Analyze the powder

1.2.5 Prepare Powder

- o Transfer the powder to the screen hopper-feeder
- o Screen the powder to size, recycling oversize powder through a grinder
- o Blend the acceptably sized powder into a master mix

1.3 Process the Offgas

- o Control negative pressure on the solution tanks, precipitator, calciner and connecting systems
- o Remove condensables, NH_3 and NH_4^+ , transferring solid and aqueous waste for processing by waste treatment.

2.0 Equipment Criteria

The following general criteria apply to all equipment within the conversion functional area:

- o Normal operation shall be performed in a fully remote mode.
- o Some "hands-on" maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o All equipment shall be designed for criticality safety. Geometry control will be used whenever possible.
- o Use of sharp corners or cavities will be minimized to reduce powder or liquid holdup in the equipment during normal operation and during shutdown and cleanout conditions.
- o Adequate parallel lines and spare equipment shall be included in the design to assure meeting the design rate of production.

3.0 Design Requirements

3.1 Process Requirements

3.1.1 Make Up Feed

The conversion system will require direct access to the Separations Plant U-Pu nitrate solution inventory. The transfer of the solution will be accomplished by manually initiating pumping of the solution from the Separations Plant to the make up feed area in pipelines critically safe by geometry. The solution will be received in an accountability tank which is monitored and alarmed to prevent an overflow condition. The tank shall be critically safe by geometry and fitted with an offgas system.

The solution will be thoroughly mixed to assure homogeneity. After mixing a representative sample of the solution shall be extracted and transported to the Analytical Laboratory for analysis. If the solution is rejected, the Separations Plant shall be notified and provided with a hard copy of the analytical results. The solution will then be pumped from the conversion area back to the Separations Plant by pipeline.

If the feed analysis is consistent with process specifications, the solution shall be transferred to a storage tank with storage capacity of 4500 liters or four processing days. The tank shall be critically safe by geometry and fitted with an offgas system. The tank contents shall be continuously monitored by the Data Acquisition System (DAS) which will maintain a permanent record of tank volume changes. The Data Logger is also connected by a data-link to the SNM transaction file.

3.1.2 Coprecipitate U and Pu

The U-Pu nitrate solution shall be mixed in the storage tank to assure homogeneity. The solution will be automatically transferred to a precipitation line accountability tank which is critically safe by geometry, provided with an offgas system, and monitored and alarmed to prevent overflow. The mixed nitrate solution and NH_4OH will be metered at a controlled rate to the continuously stirred precipitator. An average throughput of 91 Kg HM/day per precipitator shall be maintained. The precipitator pH shall be monitored continuously. An alarm will be activated if the solution pH is out of specification. When precipitation is complete, all residual precipitate shall be flushed from the system.

3.1.3 Calcine Precipitate

Slurry is transferred into the operating calciner in an automatic mode with manual override capability. Means shall be provided to unplug the transfer lines. The heavy metal mass flow rate into the calciner shall be the same as that to the precipitator; the slurry retention line shall be controlled to meet MO_x powder specifications. An intermittent vibrator system shall be provided to break up calcined cake.

The calciner operating temperature and nitrogen gas flow to the calciner shall be controlled automatically. These conditions shall be continuously recorded by the DAS. Alarms shall be set to warn of high or low temperature, high or low gas flow, or non-standard gas pressure.

An offgas processing system, provided with a filter blow-back system to keep filters operating, will separate the offgas from the powder. Differential pressure instrumentation across the filters with a readout to the DAS will check for high pressure differential signifying filter blockage. A continuous process for reducing the size of powder agglomerates without abrading any Inconel shot in the powder is necessary to separate calciner shot from powder. Equipment must function without plugging. Shot will be recycled to the calciner on a continuous basis.

Provide empty Inconel trays as needed to meet throughput requirements.* Automatically load the MO_x powder into Inconel trays and transfer from the shot^x preparation process by gravity feed to the reduction-stabilization furnace.

3.1.4 Reduce and Stabilize Powder

Set and control the argon-hydrogen flow to the reduction furnace and the carbon dioxide flow to the stabilization furnace. Set temperatures and time cycles. The preceding data shall be input to the DAS for a continuous record of flow conditions, temperature and time. High and low temperature, high and low gas flow, and gas pressure alarms will warn operators of non-standard operating conditions. The trays shall be loaded into the reduction furnace reducing the MO_x to MO_2 . After reduction, transfer the trays to the stabilization furnace which will stabilize the powder by controlled oxidation. Transfer the trays to the hopper-feeder for the powder blending operation.

* The MO_x powder could be handled by batch processing in Inconel trays as described or, alternatively, by providing a pneumatic flow transport system for continuous powder processing.

If powder will be transported by continuous pneumatic flow instead of transported in trays, powder will be collected at the calciner and moved through the reduction and stabilization furnaces using gas supplied to the furnaces for powder transport as well. An alarm triggered by excessive pressure would indicate blocked flow in the pneumatic transfer system. After stabilization the powder is cooled, separated from the offgas, and accumulated in blend tanks. The powder shall be blended into batches by means of a static blender adequate to homogenize the powder within time constraints.

A representative sample will be sent to the Analytical Laboratory for analysis. The remaining powder is stored in surge storage equivalent to two processing days production. If the product does not meet specifications, it will be transferred to Scrap Recovery with a copy of the analytical results or recycled through the reduction and stabilization process.

3.1.5 Prepare Powder

The acceptable powder shall be gravity fed onto a 200 mesh screen to a hopper feeder, then accumulated in blend tanks. Weighing will be accomplished by load cells attached to the storage tanks. The tankage (two tanks minimum) shall be capable of holding four days production for each line. A static blender adequate to assure homogeneity in the allotted time will blend the master mix. Oversize particles from the screening process shall be recycled by gravity feed through a continuous grinder capable of milling powder to less than 200 mesh.

The master mix shall be sampled and transferred to the Analytical Laboratory for confirmation that all specifications have been met.

3.1.6 Store Powder

The powder shall be transferred into storage cans in preparation for pellet fabrication.

3.1.7 Process the Offgas

Negative pressure shall be maintained on the solution tanks, precipitator, calciner and connecting systems. A negative pressure vessel vent system shall be provided. To remove condensables from the offgas, the condenser shall be supplied with sufficient cooling to remove all vapors which are condensable at room temperature. A

scrubbing tower of sufficient capacity to remove ammonia shall be provided such that scrubbed offgas meets environmental discharge standards shall be provided. Removal of NH_3 and NH_4 as a solid must be of a form suitable for packaging. Aqueous waste shall be mixed for a time adequate to assure homogeneity. Solid waste shall be accumulated in an area with two week storage capability. After verification that wastes meet acceptance specifications, they shall be transferred to Waste Treatment for further processing.

3.2 Structural Requirements

Structural design for conversion shall be a part of the integrated facility design for the overall fuel fabrication plant and shall adhere to those overall requirements.

3.3 System Configuration and Essential Features

The conversion function shall be designed for fully remote operation and maintenance. Sources of nuclear feed materials, process services, gases and chemicals shall be available as required for each station.

3.4 Maintenance

Maintenance shall be performed remotely and in-place whenever possible. That maintenance which cannot be performed in-place may be performed in a "hands-on" mode in a remote glove box after the equipment has been decontaminated and removed from the processing gallery. In order to minimize personnel exposure during maintenance, equipment shall be designed and selected to provide:

- o minimum holdup when run "dry"
- o ease of disassembly and maintenance
- o high reliability to reduce frequency of maintenance
- o minimum use of sharp corners and cavities to reduce material accumulation and holdup

In case of major equipment failure, each piece of process equipment shall be capable of being easily removed from the process and readily replaced with minimum downtime.

3.5 Surveillance and In-Source Installation

Surveillance systems shall be implemented to satisfy all federal, state and SAF requirements concerning personnel exposure, accountability control, SNM safeguards, radiation release to the environment, safety, etc. These systems will be designed, installed and maintained by the facilities function.

3.6 Instrumentation and Control

The instrumentation shall be provided for monitoring the conversion area.

3.7 Interfacing Systems

The following functions and services shall be provided by interfacing systems:

3.7.1 Material Handling

- o Transfer U-Pu nitrate solutions by pumping from the Separations Plant in pipelines.
- o Transport representative samples of nitrate solution to the Analytical Laboratory.
- o If the sample is rejected, pump the solution from conversion area back to the Separations Plant by pipeline.
- o Following reduction and stabilization, transport samples of powder to the Analytical Laboratory.
- o If the sample is rejected, transfer the powder to the Scrap Recovery area by continuous pneumatic flow.
- o Transport a representative sample of powder from the powder preparation area to the Analytical Laboratory.
- o Transport a representative sample of aqueous waste to the Analytical Laboratory.
- o Transfer aqueous waste to Waste Treatment.
- o Accumulate solid waste in two week storage area.
- o Package solid waste in transfer containers meeting low level TRU waste specifications.
- o Transport the solid waste sample to the Analytical Laboratory.
- o Transfer the solid waste to Waste Treatment facility.

3.7.2 Facilities and Support

- o U-Pu nitrate solution
- o NH_4OH
- o Source of controlled nitrogen
- o Source of controlled argon-hydrogen
- o Source of controlled air for pneumatic transfer
- o Source of controlled carbon dioxide
- o Electrical power
- o Ventilation
- o Analytical Laboratory
- o Direct communications with Analytical Laboratory
- o Direct communications with Separations Plant
- o Data Acquisition System
- o Data-links between conversion function and Analytical Laboratory, DAS, and SNM transaction file
- o Remote mechanical transfer equipment

3.8 Production and Quality Control

3.8.1 General

A calibration system shall be established for all instrumentation used for process or quality control.

3.8.2 Make Up Feed

Accuracy of volume, temperature and density measurements must meet accountability requirements.

The Analytical Laboratory is responsible for analysis of U-Pu nitrate solution for:

- 1) U Concentration $\pm$ 5%

- 2) Pu concentration $\pm 5\%$
(Heavy metal conc. = 400 g/liter
 $\pm 5\%$; Pu:U ratio $30\% \pm 1\%$)

3) U isotopic

4) Pu isotopic

5) Metallic impurities
6) Non-metallic impurities } <1000 ppm

HNO_3 2.75 M $\pm 5\%$

3.8.3 Coprecipitate U and Pu

Solution density, temperature and volume must meet accountability requirements.

3.8.4 Calcine Precipitate

No special production or quality control requirements.

3.8.5 Reduce and Stabilize Powder

The Analytical Laboratory is responsible for analysis of sample batches of powder for:

- 1) U concentration
2) Pu concentration
3) metallic impurities
4) non-metallic impurities } Total excluding Am, <2000 ppm
5) moisture content -- ≤ 0.5 wt%
6) loss-on-ignition -- ≤ 2.5 wt%
7) O/M ratio -- 2.06 - 2.15

3.8.6 Prepare Powder

The Analytical Laboratory is to perform analyses for:

- 1) U concentration

- 2) Pu concentration
 - 3) U isotopic -- TBD
 - 4) Pu isotopic -- TBD
 - 5) metallic impurities
 - 6) non-metallic impurities
 - 7) moisture content -- ≤ 0.5 wt%
 - 8) loss-on-ignition -- ≤ 2.5 wt%
 - 9) flowability -- TBD
 - 10) sinterability -- $\geq 92\%$ TD
 - 11) O/M ratio -- 2.06 - 2.15
 - 12) particle size -- < 200 mesh
- } Total excluding
Am, < 2000 ppm

3.8.7 Process the Offgas

Analyze aqueous waste for:

- 1) U concentration
- 2) Pu concentration
- 3) NH_4^+ concentration

Analyze solid waste for:

- 1) U concentration
- 2) Pu concentration

3.9 Reliability Assurance

In order to provide assurance that the process line will remain operational, the need for off-line backup units for each process step must be assessed. If implemented, equipment handling systems shall be included for transfer from an inoperative station to the off-line station as needed.

3.10 Design Safety Requirements

Standard safety design procedures shall be followed for all cell design. Equipment outside the containment shall be provided with personnel protection barriers as required. Criticality control shall be provided for all process equipment by geometry or double batch size limits based on 30 percent Pu in all equipment. Due to physical barriers, feed hoppers for natural UO_2 and non-SNM constituents need not be criticality controlled:

3.11 Radiation Shielding Requirements

Radiation shielding shall be implemented, where necessary, to assure concurrence with the SAF requirements for personnel exposure.

3.12 Safeguards Consideration

The conversion processing line shall be operated on a moving inventory basis. Monitoring systems shall be provided for measurement of ID and LEID. Building design shall include safeguards consideration. In-line retention of SNM shall be minimized and vault storage shall be utilized wherever possible.

FUNCTION 2

POWDER PREPARATION AND PELLET FABRICATION

SYSTEM DESIGN DESCRIPTION, SECTION 1

POWDER PREPARATION AND PELLET FABRICATION
SYSTEM DESIGN DESCRIPTION, SECTION 1

This section contains the specific functions, criteria and design requirements necessary for the conceptual design of a powder preparation and pellet fabrication system. This system will support a 150 MTHM/year mixed oxide fuel fabrication facility which will contain both wet and dry scrap recovery processes.

RDT Standard F1-2T, "Preparation of System Design Descriptions", dated September, 1975 was used as the basis for preparation of this System Design Description (SDD).

1.0 Functions

1.1 General

- o The requirements established in the SAF analysis (product, process and SAF requirements) shall be met as part of this design.
- o The design shall incorporate fully remote operation. Some contact maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Support functions have been identified in the powder preparation and pellet fabrication interface diagram and are assumed to be provided as necessary.
- o Each station shall be capable of operation in an automatic mode but shall be equipped with manual over-ride capabilities for non-steady state operations.
- o Powder transfers between stations and/or storage are assumed to occur by some given method and are not considered as part of this SDD.
- o Each station shall be provided with the capability of performing the SNM transactions necessary to meet accountability requirements.

1.2 Powder Preparation

1.2.1 Powder Receiving

- o Receive and provide temporary storage for incoming UO_2 and COMOX feed powders as well as product from Scrap Recovery.

- o Verify container identification.
- o Verify accountability weights of incoming container and contents.
- o Verify container contents.

1.2.2 Batch Makeup

- o Meter and weigh UO_2 and COMOX feed powders as well as recycled powder blends.
- o Transfer powder batch to the blender.

1.2.3 Blending and Milling

- o Mix powder constituents together to homogenize UO_2/PuO_2 .
- o Break up powder agglomerates.

1.2.4 Blend Storage

- o Transfer blended powder to storage area
- o Sample for composition and chemical attribute verification

1.3 Pellet Fabrication

1.3.1 Precompaction

- o Predensity the powder.
- o Transfer compacted powder to granulation area.

1.3.2 Granulate and Sieve

- o Segregate granules and recycle over and under size fractions to precompaction.
- o Add and mix pressing lubricant with granules.
- o Transfer granules mixed with lubricant to pressing area.

1.3.3 Press Pellets

- o Compact granules into specific size and density pellets.
- o Sort pellets and segregate size and density rejects.
- o Transfer pellets to boat loading area.

1.3.4 Boat Loading/Storage

- o Load pressed green pellets into sintering boats.
- o Record the identity, gross and tare weights for each boat.
- o Transfer boats to temporary storage.
- o Provide temporary storage for loaded boats.

2.0 Equipment Criteria

The following general criteria apply to all equipment within the powder preparation and pellet fabrication functional area:

- o Normal operation shall be performed in a fully remote mode.
- o Some "hands-on" maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o All equipment shall be designed for criticality safety. Geometry control will be used whenever possible.
- o Use of sharp corners or cavities will be minimized to reduce powder/liquid holdup in the equipment during normal operation as well as shutdown/cleanout conditions.
- o Equipment shall be easily disassembled and maintained under remote and/or glove box conditions.
- o Adequate parallel lines and spare equipment shall be included in the design to assure meeting the design rate of production.

3.0 Design Requirements

3.1 Process Requirements

3.1.1 Process Line Capacity

The powder preparation and pellet fabrication function shall be capable of producing 178.4 MTHM/year of mixed oxide for delivery to the sintering function. This production requirement which is larger than the 150 MTHM/year capacity of the SAF results from recycle scrap generated by both internal and external sources within the overall processes.

3.1.2 Powder Preparation

3.1.2.1 Powder Receiving

The necessary feed powders are received from the storage areas by the feed hoppers in the batch weighing system. The powder feed hoppers shall be specially designed, geometrically safe (for criticality control), cylindrical stainless steel vessels. They shall be equipped with a weigh cell, "high powder level" detector, internal porous metallic filters, mechanical vibrator, pressure sensors, and a discharge valve. The feed hoppers are physically located at an elevation to allow for gravity discharge of its contents into the associated weigh hoppers. The powder feed hoppers shall be sized as follows and will receive powder from the designated storage areas:

<u>Powder</u>	<u>Feed Hopper Capacity</u>	<u>Storage Area</u>
COMOX	80 Kg	Conversion
UO ₂ (depleted)	50 Kg	UO ₂ Storage
COMOX Recycle	40 Kg	Dry Scrap Recycle

Each of these powders shall be certified for assay, impurities and physical testing as well as any internal process material requirements.

3.1.2.2 Batch Make Up

The batch make up system shall meter and weigh each of the three powder components in predetermined proportions to make up a batch for blending. Each powder is transferred to its respective weigh hopper which has been checked for calibration and set to receive the programmed quantity. Weighing precision and accuracy shall be adequate to assure meeting of the blend fissile requirement within the prescribed tolerance as specified in the process specification.

The weighing systems shall be computer controlled. Using fissile content, percent metal and impurity values from its data base, the computer shall automatically establish the amount of each constituent needed to yield the desired feed material for pellet production. It shall then control the vibratory feeders to sequentially add the required amount of each constituent into each weigh hopper. Each feeder shall be controlled in two steps, high flow and dribble for the last 5 percent of the desired weight at approximately 20 percent of high flow. The weighing system shall provide feedback to the central data base for the actual weight of each constituent added.

The weigh hoppers shall be located directly above the blender and shall receive all material for the batch and verify the weight of each constituent against the weight loss of each feed hopper. When all weights have been verified, the batch weigh hoppers shall be lowered to make sealed connection with the blender and a valve in the bottom of the hopper opened to transfer all material into the blender.

The batch make up system shall be capable of receiving recycled powder blends which fail to meet compositional requirements and which require adjustments to be made by the incremental additions of one or more components.

3.1.2.3 Blending and Milling

The blending and milling system shall homogenize the powder mixture to meet both bulk and micro-homogeneity requirements. The processing system

shall be constructed in a critically safe geometry with a maximum capacity of 130 Kg of powder. A typical sub-blend will be approximately as follows for nominal 20% Pu fuel:

COMOX	67.2 Kg
UO ₂	33.6 Kg
Recycle MO _x	<u>19.0 Kg</u>
	120.0 Kg

Either the blending or milling operation must impact a high energy shearing action to disperse agglomerates in the powder.

3.1.2.4 Blend Storage

The powder batches are transferred from the blending and milling operations to MO_x powder storage silos. The storage silos shall be geometrically safe (for criticality control) stainless steel slab or cylindrical vessels which are sized to accommodate 150 Kg of powder. Each silo is equipped with a weigh system, high powder level control, internal porous filter system, pressure sensors, mechanical vibrator, discharge valve, powder rate feeder, and connection to the material transport system. The weigh system is provided both for inventory purposes and to determine that discharge of powder is complete. Residual holdup detectors are required to ensure that no significant quantities of powder remain in the silos. During the transfer, or after the transfer, a representative sample is withdrawn to be analyzed for verification of composition and chemical attributes.

3.1.3 Pellet Fabrication

3.1.3.1 Precompaction

The powder precompaction area shall receive powder from the blend storage area in a feed

hopper system. The hopper shall be sized to accommodate at least one sub-blend batch of material. The feed hopper contains high and low-level sensors for powder level control. It is also load cell mounted for monitoring of contained mass of material. Discharge from this hopper shall be through a rate feeder into the feeder of the precompaction press. Compacts measuring 2 to 4 inches in diameter and approximately 0.5 inches in thickness shall be pressed at 50-60 percent of theoretical density. Provisions must be included for recycle of granulator fines from the granulate and sieve operation.

3.1.3.2 Granulate and Sieve

The precompacted material which discharges from the precompaction press into the granulator shall be fragmented into particles or granules between 14 and 160 mesh size. The fines and oversized granules shall be separated from the granulated powder. The oversized material is recycled through the granulator while the fines are routed through the precompaction operation. The separator unit shall consist of four segregated chambers (each with its own exit port) fed, activated, and excited by vibratory action. The chambers are separated by three screens. The first chamber removes broken screen strands coming from the granulator while the second chamber removes oversize granules of product. The oversize granules are recycled through the granulation operation. The third chamber removes the properly sized product granules allowing any fines to pass through the screen. The bottom chamber collects the fines and feeds them to a rotary valve feeder which returns them to the precompaction feed hopper. The product granules are fed to the press lubrication addition station.

Samples for sinterability testing shall be drawn from the batch following granulation and sieving, if required. Sinterability testing will normally be performed when:

- o master mix of UO_2 feed lots change

- o amount of recycle scrap changes
- o feed requirements to pellet presses changes
- o feedback from sintered pellet inspection indicates a problem.

A pressing lubricant shall be mixed with the granules prior to pellet pressing. The lubricant shall be received certified from non-secure storage and delivered to a hopper and feed system. Granules shall be delivered directly to a continuous low energy blender which can be emptied and cleaned. Blending must produce a homogeneous dispersal of the lubricant without destroying the granules. At the completion of the blending cycle, the granules will be discharged.

3.1.3.3 Pellet Pressing

The pellet pressing area shall be equipped with automatic feed from the lubrication blending area. The area shall contain one or more presses which may utilize multi-cavity dies. The press hopper which receives granules shall be a load cell mounted vessel for monitoring the quantity of granules it contains as well as their level. It shall be gravity discharged at the rate demanded by the press. Aeration gas may be desirable to facilitate flow. The green pellets will have a diameter in the range 0.1 to 0.3 inches and a length to diameter ratio of approximately 1.0. Selected green pellets shall be measured as to their weight and dimensions during transfer to the boat loading station. Rejected pellets are recycled to the granulation operation.

3.1.3.4 Boat Loading

Green pellets are removed from the press and collected into sintering boats. The latter are to contain a controlled amount of pellets by weight (or volume) and may be either stacked or random loaded. The identity, gross and tare weights of each boat are recorded, and the boats temporarily stored to await sintering.

3.2 Structural Requirements

Structural design for powder preparation and pellet fabrication shall be a part of the integrated facility design for the overall fuel fabrication plant and shall adhere to those overall requirements.

3.3 System Configuration and Essential Features

Powder preparation and pellet fabrication shall be designed for fully remote operation and maintenance. Sources of nuclear feed materials, process services, gases and chemicals shall be available as required for each station.

3.4 Maintenance

Maintenance shall be performed remotely and in-place whenever possible. That maintenance which cannot be performed in-place may be performed in a "hands-on" mode in a remote glove box after the equipment has been decontaminated and removed from the processing gallery. In order to minimize personnel exposure during maintenance, equipment shall be designed and selected to provide:

- o minimum holdup when run "dry"
- o ease of disassembly and maintenance
- o high reliability to reduce frequency of maintenance
- o minimum use of sharp corners and cavities to reduce material accumulation and holdup

In case of major equipment failure, each piece of process equipment shall be capable of being easily removed from the processing gallery and readily replaced with minimum downtime.

3.5 Surveillance and In-Source Installation

Surveillance systems shall be implemented to satisfy all federal, state and SAF requirements concerning personnel exposure, accountability control, SNM safeguards, radiation release to the environment, safety, etc. These systems will be designed, installed and maintained by the facilities function.

3.6 Instrumentation and Control

The instrumentation shall be provided for monitoring the powder preparation and pellet fabrication areas.

3.7 Interfacing Systems

The following functions and services shall be provided by interfacing systems:

3.7.1 Material Handling

- o Transfer of all mixed oxide powders and UO_2 from storage to the feed hoppers in the batch make up area.
- o Transfer of powder from the blending area to blend storage.
- o Transfer of all powders from the blend storage to the precompaction press hopper.
- o Transfer of all granules from the granulation area to the lubrication addition area.
- o Transfer of the lubricant from storage to the lubricant feed hoppers.
- o Transfer of the powders from the lubricant blending area to the press feed hopper.
- o Transfer of the green pellets to the sintering boats.
- o Transfer of loaded sintering boats to storage.

3.7.2 Facilities and Support

- o Coprocessed mixed oxides (approximately 250 Kg/day)
- o Uranium dioxide
- o Scrap recycle powder
- o Die lubricant
- o Electrical power
- o Nitrogen

- o Cooling water
- o Compressed air
- o Vacuum
- o Hydraulic fluid
- o Ventilation
- o Remote manipulators, including maintenance and repair
- o Crane and track for transfer of equipment
- o Decontamination/maintenance glove box
- o Analytical Laboratory
- o Accountability for Powder Preparation and Pellet Fabrication function
- o In-line nondestructive assay (NDA) equipment

3.8 Production and Quality Control

3.8.1 General

A calibration system shall be established for all instrumentation used for process or quality control.

3.8.2 Powder Preparation

3.8.2.1 Powder Receiving

Uranium dioxide, coprocessed mixed oxide powder, recycle scrap, and lubricant shall be received certified to the applicable specification.

3.8.2.2 Batch Make Up

No special production and quality control requirements.

3.8.2.3 Blending and Milling

No special production and quality control requirements.

3.8.2.4 Blend Storage

On-line instrumentation shall be provided for rapid evaluation of Pu content, i.e., < 1/2 hour for 5 samples.

3.8.3 Pellet Fabrication

3.8.3.1 Precompaction

Equipment shall be provided to automatically measure the length and diameter of the pressed pellets as well as determine green density.

3.8.3.2 Granulate and Sieving

Equipment shall be provided by the analytical laboratory function for accelerated sinterability testing of powder batches. The sinterability test line shall consist of small scale lubricant blending, pellet pressing, sintering and grinding equipment, and dimensional and density inspection instrumentation. Turnaround time shall not exceed 4 hours.

3.8.3.3 Die Lubricant Addition Area

No special production or quality control requirements.

3.8.3.4 Pellet Pressing

Equipment shall be provided to automatically measure the length and diameter of pressed pellets as well as determine green density.

3.8.3.5 Boat Loading

Equipment shall be provided to determine the weight of each sintering boat and maintain the pressing identity of the pellets.

3.9 Reliability Assurance

In order to provide assurance that the process line will remain operational, the need for off-line backup units for each process step must be assessed. If implemented, equipment handling systems shall be included for transfer from an inoperative station to the off-line station as needed.

3.10 Design Safety Requirements

Standard safety design procedures shall be followed for all cell design. Equipment outside the containment shall be provided with personnel protection barriers as required. Criticality control shall be provided for all process equipment by geometry or double batch size limits based on 30 percent Pu in all equipment. Due to physical barriers, feed hoppers for natural UO_2 and non-SNM constituents need not be criticality controlled.

3.11 Radiation Shielding Requirements

Radiation shielding shall be implemented, where necessary, to assure concurrence with the SAF requirements for personnel exposure.

3.12 Safeguards Considerations

The Powder Preparation and Pellet Fabrication processing line shall be operated on a moving inventory basis. Monitoring systems shall be provided for measurement of ID and LEID. Building design shall include safeguards consideration. In-line retention of SNM shall be minimized and vault storage shall be utilized wherever possible.

FUNCTION 3

SINTERING AND PIN LOADING
SYSTEM DESIGN DESCRIPTION, SECTION 1

SINTERING AND PIN LOADING
SYSTEM DESIGN DESCRIPTION, SECTION 1

This section contains the specific functions, criteria and design requirements necessary for the conceptual design of a sintering and pin loading system. This system will support a 150 MTHM/year mixed oxide fuel fabrication facility which will contain both wet and dry scrap recovery processes.

RDT Standard F1-2T, "Preparation of System Design Descriptions", dated September, 1975 was used as the basis for preparation of this System Design Description (SDD).

1.0 Functions

1.1 General

- o The requirements established in the SAF analysis (product, process and SAF requirements) shall be met as part of this design.
- o The design shall incorporate fully remote operation. Some contact maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Support functions have been identified in the sintering and pin loading interface diagram and are assumed to be provided as necessary.
- o Each station shall be capable of operation in an automatic mode but shall be equipped with manual over-ride capabilities for non-steady state operations.
- o Powder transfers between stations and/or storage are assumed to occur by some given method and are not considered as part of this SDD.
- o Each station shall be provided with the capability of performing the SNM transactions necessary to meet accountability requirements.

1.2 Sintering Area

1.2.1 Sintering

- o Receive green pellets loaded into sintering boats
- o Verify sintering boat identity and contents
- o Load sintering boats into the furnace
- o Sinter pellets at the appropriate time/temperature/atmosphere conditions

- o Unload sintering boats from the furnace
- o Inspect sintered pellet diameter and density for process control
- o Store sintered pellets prior to grinding

1.2.2 Grinding

- o Receive sintered pellets in boats
- o Empty boats into the pellet feeder system
- o Return empty sintering boats to the pressing area
- o Grind sintered pellets to specific diameter
- o Inspect ground pellet diameter for process control

1.3 Pin Loading Area

1.3.1 Sintered Pellet Inspection

- o Receive pellets from the grinding area
- o Inspect pellets for chemical and physical properties
- o Store inspected pellets

1.3.2 Pin Loading

- o Prepare and measure pellet columns for loading
- o Load pellet columns and hardware into prepared clads
- o Inspect/decontaminate fuel pins for welding
- o Store inspected pins

1.3.3 Pin Welding Area

- o Receive loaded fuel pins in welding lots
- o Insert final hardware into fuel pins

- o Evacuate fuel pins and back fill with helium
- o Weld fuel pins
- o Inspect fuel pins and store

2.0 Equipment Criteria

The following general criteria apply to all equipment within the sintering and pin loading functional area:

- o Normal operation shall be performed in a fully remote mode.
- o Some "hands-on" maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o All equipment shall be designed for criticality safety. Geometry control will be used whenever possible.
- o Use of sharp corners or cavities will be minimized to reduce powder/liquid holdup in the equipment during normal operation as well as shutdown/cleanout conditions.
- o Equipment shall be easily disassembled and maintained under remote and/or glove box conditions.
- o Adequate parallel lines and spare equipment shall be included in the design to assure meeting the design rate of production.

3.0 Design Requirements

3.1 Process Requirements

3.1.1 Process Line Capacity

The sintering and pin loading function shall be capable of producing 164.4 MTHM/year of mixed oxide for delivery to the bundle assembly function. This production requirement which is larger than the 150 MTHM/year capacity of the SAF process results from recycle scrap generated by both internal and external sources within the overall processes. All processing equipment with the exception of the sintering furnaces will be operated 24 hours/day, 5 days/week. The sintering furnaces will be operated on a 24 hours/day, 7 days/ week schedule.

3.1.2 Sintering Area

3.1.2.1 Sintering

One or more reductive atmosphere sintering furnaces will be required to meet the processing throughput requirements. During the sintering operation the fuel pellets must experience a heat treatment of $1700 \pm 50^{\circ}\text{C}$ for a minimum of 4 hours to achieve the average 90.4 percent theoretical sintered density. The sintering atmosphere shall be 6 percent hydrogen in an argon carrier gas with a variable oxygen partial pressure input (maximum 5×10^{-11} atmosphere) in the cooldown portion of the furnace to produce the desired fuel pellet stoichiometry.

The sintering furnace shall be equipped with a mechanized control atmosphere interlock system to contain the reducing atmosphere inside the furnace as well as prevent oxygen or air from entering into the main sintering area. The interlocks shall be incorporated with a boat pusher mechanism which sequentially processes boats through the furnaces, empties the pellets after sintering, and returns the empty boats to the press area for reuse. The interlock system shall be equipped with viewing ports so the movement of sintering boats into the furnaces can be easily observed.

The maximum temperature the sintering system might experience is 1750°C . The furnace shall be designed to accommodate 50 psig internal pressure for short periods of time (less than 5 minutes). The furnace will be routinely operated at 5 to 10 inches of water pressure.

The sintering furnace shell, interlocks, and loading/unloading areas shall be constructed from stainless steel. The refractory portion of the furnace shall contain high purity alumina or an equivalent refractory with silicon content as low as practically possible ($<0.1\%$). The furnace refractory system may be designed so that water cooling is utilized to maintain a surface temperature $<75^{\circ}\text{C}$. The cooldown portion of the furnace shall be air or water cooled such that boats enter the exit interlock at not more than 50°C .

3.1.2.2 Grinding

The grinder(s) shall be capable of handling nominal 0.25 inch diameter fuel pellets at an instantaneous axial rate of approximately 100 in/min.

Each grinder shall utilize diamond wheels and all grinding shall be accomplished dry. Provisions must be included for monitoring the pellet diameters after grinding to provide feedback for size control. The pellets shall be moved through the grinding area in a single column to the inspection/storage area. Identity of the fuel pellets shall be maintained by press location and sintering cycle.

A collection system shall be incorporated with the grinder to collect the fine dust-like powder produced during the dry grinding operation.

3.1.3 Pin Loading Area

3.1.3.1 Sintered Pellet Inspection

One or more inspection systems will receive fuel pellets in an axial column from the grinding area. These physical properties inspection systems shall inspect a statistical sample of pellets for diameter, length, density, cracks, pits, chips, end perpendicularity, and ovality. The acceptable pellets will be sampled for impurities, oxygen-to-metal ratio, moisture, absorbed gas, homogeneity, metal concentrations and fissile content. These analyses will be performed by either an in-line nondestructive assay (NDA) system or transferred to an analytical chemistry laboratory for analysis. After completion of sampling and inspection operations, the fuel pellets will be stored by production lot for release to the fuel pin loading function.

3.1.3.2 Pin Loading

Pellet column measuring and loading stations capable of handling 0.25" fuel pellets will be required to meet the pin loading throughput requirements. The loading operation will be

conducted in a vacuum valve and/or contamination free arrangement to reduce contamination during welding. Adequate storage space is required to accumulate loaded pins for weld cycles.

3.1.3.3 Pin Welding Area

Pin welding stations capable of handling 0.25" fuel pins will be required to meet the pin welding throughput requirements. The pin welding operation will be conducted by fuel pin evaluation, backfilling with helium, and welding to produce contamination free fuel pins. Adequate storage space is required to accumulate welded fuel pins for bundle assembly.

3.2 Structural Requirements

Structural design for the sintering and pin loading functions shall be a part of the integrated facility design for the overall fuel fabrication plant and shall adhere to those overall requirements.

3.3 System Configuration and Essential Features

The sintering and pin loading functions shall be designed for fully remote operation and maintenance. Sources of nuclear feed materials, process services, gases and chemicals shall be available as required for each station.

3.4 Maintenance

Maintenance shall be performed remotely and in-place whenever possible. That maintenance which cannot be performed in-place may be performed in a "hands-on" mode in a remote glove box after the equipment has been decontaminated and removed from the processing gallery. In order to minimize personnel exposure during maintenance, equipment shall be designed and selected to provide:

- o minimum holdup when run "dry"
- o ease of disassembly and maintenance
- o high reliability to reduce frequency of maintenance
- o minimum use of sharp corners and cavities to reduce material accumulation and holdup
- o In case of major equipment failure, each piece of process equipment shall be capable of being easily removed from the process and readily replaced with minimum downtime.

3.5 Surveillance and In-Source Installation

Surveillance systems shall be implemented to satisfy all federal, state and SAF requirements concerning personnel exposure, accountability control, SNM safeguards, radiation release to the environment, safety, etc. These systems will be designed, installed and maintained by the facilities function.

3.6 Instrumentation and Control

The instrumentation shall be provided for monitoring the sintering and pin loading areas.

3.7 Interfacing Systems

The following functions and services shall be provided by interfacing systems:

3.7.1 Material Handling

3.7.1.1 Sintering Area

- o Transfer of green pellets loaded into sintering boats from storage to the sintering furnace controlled atmosphere interlock system.
- o Transfer of sintered pellets from the sintering furnace to the grinding system
- o Transfer of ground pellets to the inspection area
- o Transfer of all scrap and waste to the appropriate areas
- o Transfer of empty boats back to the pellet pressing area

3.7.1.2 Pin Loading Area

- o Transfer of samples to an analytical chemistry laboratory or NDA instrumentation
- o Transfer of samples to the physical properties and dimensions inspection area
- o Transfer of sampled and inspected pellets to a storage area

- o Transfer of pellets and hardware to the pin loading area
- o Transfer of loaded pins to storage and welding areas
- o Transfer of weld samples to a weld inspection area
- o Transfer of final hardware to the welding area
- o Transfer of fuel pins to storage

3.7.2 Facilities and Support

- o Green pressed pellets in sintering boats
- o Scrap recycle powder
- o Die lubricant
- o Electrical power
- o Nitrogen
- o 6% H₂ - Argon
- o Carbon Dioxide
- o Cooling water
- o Compressed air
- o Vacuum
- o Ventilation
- o Remote manipulators, including maintenance and repair
- o Crane and track for transfer of equipment
- o Decontamination/maintenance glove box
- o Analytical Chemistry Laboratory
- o Reactor grade helium
- o Accountability for Sintering and Pin Loading function
- o In-line NDA equipment

3.8 Production and Quality Control

3.8.1 General

A calibration system shall be established for all instrumentation used for process or quality control.

3.8.2 Sintering Area

3.8.2.1 Sintering

Equipment shall be provided for measurement of sintered pellets, dimensions, density, gas content and oxygen-to-metal ratio and shall provide feedback information for process control only. No quality control measurements will be made in this area.

3.8.2.2 Grinding

Equipment shall be provided for measurement of ground pellet diameter and shall provide feedback information for process control only. No quality control measurements will be made in this area.

3.8.3 Pin Loading Area

3.8.3.1 Sintered Pellet Inspection

Equipment must be provided for final pellet geometry inspection, oxygen-to-metal ratio, moisture, absorbed gas, impurities, metal concentrations, fissile content and homogeneity. These analyses can be performed either in-line or at a special analytical area after removal of the samples from the pin loading area.

3.8.3.2 Pin Loading

Equipment shall be provided for measurement of fuel column lengths and weights as well as fuel pin contamination levels.

3.8.3.3 Pin Welding Area

Equipment shall be provided for measurement of fuel pin contamination and for fuel pin inspection.

3.9 Reliability Assurance

In order to provide assurance that the process line will remain operational, the need for off-line backup units for each process step must be assessed. If implemented, equipment handling systems shall be included for transfer from an inoperative station to the off-line station as needed.

3.10 Design Safety Requirements

Standard safety design procedures shall be followed for all cell design. Equipment outside the containment shall be provided with personnel protection barriers as required. Criticality control shall be provided for all process equipment by geometry or double batch size limits based on 30 percent Pu in all equipment. Due to physical barriers, feed hoppers for depleted UO_2 and non-SNM constituents need not be criticality controlled.

3.11 Radiation Shielding Requirements

Radiation shielding shall be implemented, where necessary, to assure concurrence with the SAF requirements for personnel exposure.

3.12 Safeguards Considerations

The sintering and pin loading process line shall be operated on a moving inventory basis. Monitoring systems shall be provided for measurement of ID and LEID. Building design shall include safeguards consideration. In-line retention of SNM shall be minimized and vault storage shall be utilized wherever possible.

FUNCTION 4

ASSEMBLY FABRICATION

SYSTEM DESIGN DESCRIPTION, SECTION 1

ASSEMBLY FABRICATION
SYSTEM DESIGN DESCRIPTION, SECTION 1

This section contains the specific functions, criteria and design requirements necessary for the conceptual design of an assembly fabrication system. This system will support a 150 MTHM/year mixed oxide fuel fabrication facility.

RDT Standard F1-2T, "Preparation of System Design Descriptions", dated September, 1975, was used as the basis for preparation of this System Design Description (SDD).

1.0 Functions

1.1 General

- o The requirements established in the Secure Automated Fabrication analysis (product, process and SAF requirements) shall be met as part of this design.
- o The design shall incorporate fully remote operation. Some contact maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Support functions have been identified in the interface diagram and are assumed to be provided as necessary.
- o Each station shall be capable of operation in an automatic mode but shall be equipped with manual over-ride capabilities for non-steady state operations.
- o Each station shall be provided with the capability of performing the SNM transactions necessary to meet accountability requirements.

1.2 Fuel Pin Receipt

- o Provide temporary storage for in-process pins.
- o Verify pin identification.
- o Perform incoming pin quality inspections.
- o Rework reject pins.
- o Release inspected pins to assembly.

1.3 Pin Wire Wrap

- o Provide storage for wire.
- o Perform wire wrapping and welding of fuel pins.
- o Perform quality inspection of wrapped pin.
- o Perform rework of reject pins with defective wire wrapping.
- o Provide in-process storage for both pins and wire-wrapped pins.

1.4 Pin Row Assembly

- o Assemble pins into assembly rows.
- o Inspect assembly row.
- o Provide rework for failed rows.
- o Provide in-process storage for released row assemblies.

1.5 Addition of Lower End Fitting

- o Provide in-process storage for row assemblies and lower end fittings.
- o Attach rows to lower end fitting.
- o Inspect partial assembly.
- o Provide partial assembly rework capability.
- o Provide in-process storage for partial assemblies.

1.6 Duct Addition

- o Provide in-process storage for ducting and partial assemblies.
- o Weld duct to the partial assembly.

- o Perform duct weld inspection.
- o Provide reject duct assembly rework capability.
- o Provide in-process storage for welded duct assemblies.

1.7 Addition of Upper End Fitting

- o Provide in-process storage for welded duct assemblies & upper end fittings.
- o Weld upper end fitting to the assembly.
- o Inspect finished assembly.
- o Perform final assembly inspection.
- o Provide rework capability.
- o Provide interim storage for finished assemblies.

2.0 Equipment Criteria

The following general criteria apply to all equipment within the assembly fabrication functional area:

- o Normal operation shall be performed in a fully remote mode.
- o Some "hands-on" maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o All equipment shall be designed for criticality safety. Geometry control will be used whenever possible.
- o Use of sharp corners or cavities will be minimized to reduce material holdup in the equipment during normal operation and during shutdown/cleanout conditions.
- o Equipment shall be easily disassembled and maintained under remote and/or glove box conditions.
- o Adequate parallel lines and spare equipment shall be included in the design to assure meeting the design rate of production.

3.0 Design Requirements

3.1 Process Requirements

3.1.1 Process Line Capacity

The assembly fabrication area shall be capable of producing 150.3 MTHM/year mixed oxide for delivery to the reactor as finished fuel assemblies. All processing equipment will be operated 15 hours/ day, 5 days per week.

3.1.2 Fuel Pin Receipt

The fuel pin receipt station shall receive pins released for assembly. Upon receipt, the pins shall be checked to verify pin identification and to verify that all quality checks have been performed. If all verifications are positive, the pins will be released to in-process storage, and ultimately assembly. If any verifications are negative, the pins will be sent back to the vault awaiting final disposition to rework.

3.1.3 Pin Wire Wrap

Five wire wrap stations will be required to meet the processing requirements. Each station shall be capable of wrapping 48 pins/hour. The wrapping operation will consist of positioning the pin in a fixture, spiral-wrapping the pin with the wire and welding the wire to the pin at each end-cap. Upon completion of the wrapping operation, the pins will be inspected to assure completion of the spiral wrap and bonding of the wire to the pin. Any reject wraps will be removed from the wrapping operation and reworked in the assembly area or dispositioned to Scrap Recovery. Accepted wrapped pins will be placed in in-process storage, awaiting release to pin row assembly.

3.1.4 Pin Row Assembly

Three pin row assembly stations will be required to meet the processing requirements. Each station shall be capable of assembling 8 rows/hour. The row assembly operation will consist of joining the individual fuel pins to form row assemblies utilizing row assembly fixtures. Upon completion of the row assembly, the finished rows will be inspected to assure conformance to the process specifications. Reject row assemblies will be removed from the process line for rework or disposition to Scrap Recovery. Accepted row assemblies will be placed in in-process storage, awaiting release to pin row assembly.

3.1.5 Addition of Lower End Fitting

Three weld stations will be required to attach the lower end fitting to the pin rows. Each station shall be capable of welding 0.4 assemblies/hr. Standard inert gas welding will be used to join the fitting to the pin rows. The welds will be inspected to assure conformance to quality specifications. Upon completion of the inspection, the released partial assemblies will be placed in in-process storage awaiting release to duct addition. Failed partial assemblies shall be placed in in-process storage awaiting rework.

3.1.6 Duct Addition

Two weld stations will be required to attach the duct to the partial assembly. Each station shall be capable of welding 0.6 partial assemblies/hour. After receipt of each partial assembly, that assembly will be selectively matched with its partner duct to assure a proper fit. Standard inert gas welding will be used to join the duct and the partial assembly. The welds will be inspected to assure conformance to quality specifications. Upon completion of the inspection, the released weld duct assemblies will be placed in in-process storage awaiting release to the upper end fitting weld station. Reject duct assemblies will be placed in in-process storage awaiting re-work.

3.1.7 Addition of Upper End Fitting

Two weld stations will be required to attach the upper end fitting to the duct assembly. Each station shall be capable of welding 0.6 duct assemblies/hour. After receipt of each duct assembly, that assembly will be selectively matched with its partner upper end fitting to assure a proper match. Standard inert gas welding will be used to join the fitting to the assembly. All welds will be inspected to assure conformance to quality specifications. Upon completion of the inspection, the released assemblies will be placed in in-process storage awaiting release to final inspection. Reject assemblies will be placed in in-process storage awaiting re-work.

3.1.8 Final Assembly Inspection

Four stations will be required for final assembly inspection. Each station shall be capable of inspecting 0.3 assemblies/hour. The final assemblies shall be inspected to assure conformance to the design drawings and specifications. Upon completion of the inspection, the identification number of each assembly shall be noted and recorded. Then the assembly will be transferred to storage awaiting shipment to the reactor.

3.2 Structural Requirements

Structural design for the assembly fabrication function shall be a part of the integrated function design for the overall fuel fabrication plant and shall adhere to those requirements.

3.3 System Configuration and Essential Features

The assembly fabrication function shall be designed for fully remote operation and some contact maintenance. Sources of nuclear feed materials, process services and gases and chemicals shall be available as required for each station.

3.4 Maintenance

Maintenance shall be performed in a "hands-on" mode through utilization of appropriate shielding. In order to minimize personnel exposure during maintenance, equipment shall be designed and selected to provide:

- o minimum holdup when run "dry"
- o ease of disassembly and maintenance
- o high reliability

In case of major equipment failure, each piece of process equipment shall be capable of being easily removed from the process and readily replaced with minimum downtime.

3.5 Surveillance and In-Source Installation

Surveillance and systems shall be implemented to satisfy all federal, state and SAF requirements concerning personnel exposure, accountability control, SNM safeguards, radiation release to the environment, safety etc. These systems will be designed, installed and maintained by the facilities function.

3.6 Instrumentation and Control

The instrumentation shall be provided for monitoring the Assembly Fabrication area.

3.7 Interfacing Systems

The following functions and services shall be provided by interfacing systems:

3.7.1 Material Handling

- o Transfer of released pins to the assembly area
- o Transfer of raw materials (wire wrap, upper and lower end fittings, and duct) to the assembly area
- o Transfer of final assembly to the shipping area
- o Transfer of all scrap and waste to the appropriate areas
- o Transfer of samples to the analytical chemistry lab or NDA instrumentation

3.7.2 Facilities and Support

- o electrical power
- o vacuum
- o welding gas
- o remote viewing system
- o compressed air
- o ventilation
- o analytical chemistry lab
- o in-line NDA equipment

3.8 Production and Quality Control

The following inspections/analyses will be required:

- o weld inspection at the wire wrap, upper end fitting, lower end fitting and duct stations
- o wire pitch inspection
- o pin bow inspection
- o pin row inspection
- o determination of assembly envelope dimensions
- o metallographic analyses

3.9 Reliability Assurance

In order to provide assurance that the process line will remain operational, the need for off-line backup units for each process step must be assessed. If implemented, equipment handling systems shall be included for transfer from an inoperative station to the off-line station as needed.

3.10 Design Safety Requirements

Standard safety design procedures shall be followed for all cell design. Equipment outside the containment shall be provided with personnel protection barriers as required. Criticality control shall be provided for all process equipment by geometry or double batch size limits based on 30 percent Pu in all equipment. Due to physical barriers, feed hoppers for depleted UO_2 and non-SNM constituents need not be criticality controlled.

3.11 Radiation Shielding Requirements

All continuously occupied work areas shall be limited to <0.5 mrem/hour. Areas limited to intermittent occupancy shall not exceed 5 mrem/hour. A decontamination/maintenance glove box shall be provided for equipment which must be removed for repair. Radiation exposure shall be minimized by removing SNM and cleaning equipment prior to "hands-on" maintenance.

3.12 Safeguards Considerations

The Assembly Fabrication Area shall be operated on a moving inventory basis. Monitoring systems shall be provided for measurement of ID and LEID. Building design shall include safeguards consideration. In-line retention of SNM shall be minimized and vault storage shall be utilized wherever possible.

FUNCTION 5

SCRAP RECOVERY

SYSTEM DESIGN DESCRIPTION, SECTION 1

SCRAP RECOVERY

SYSTEM DESIGN DESCRIPTION, SECTION 1

This section contains the specific functions, criteria and design requirements necessary for the conceptual design of a scrap recovery system. This system will support a 150 MTHM/year mixed oxide fuel fabrication facility and will contain both wet and dry scrap recovery processes. The total design throughput for wet and dry scrap recovery is projected to be 26.2 MTHM/year.

RDT Standard F1-2T, "Preparation of System Design Descriptions", dated September, 1975, was used as the basis for preparation of this Systems Design Description (SDD).

1.0 Functions

1.1 General

- o The requirements established in the Secure Automated Fabrication analysis (product, process and SAF requirements) shall be met as part of this design.
- o The design shall incorporate fully remote operation. Some contact maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Support functions have been identified in the scrap recovery interface diagram and are assumed to be provided as necessary.
- o Each station shall be capable of operation in an automatic mode but shall be equipped with manual over-ride capabilities for non-steady state operations.
- o Powder transfers between stations and/or storage are not considered as part of this SDD.
- o Liquid transfers shall be accomplished by the vacuum/vent method.
- o Liquid recirculation and blending shall be accomplished by pump circulation.
- o Each station shall be provided with the capability of performing the SNM transactions necessary to meet accountability requirements.

1.2 Dry Scrap Recovery

1.2.1 Feed Preparation

1.2.1.1 Scrap Receipt

- o Receive and provide temporary storage for incoming scrap.
- o Verify container identification.
- o Verify accountability weight of incoming
- o Verify container contents

1.2.1.2 Crush Scrap

- o Reduce average particle size of feed material
- o Segregate/recycle oversized material.
- o Weigh crushed product and load into furnace boats.

1.2.2 Scrap Oxidation

- o Oxidize crushed MO_2 to a $\text{U}_3\text{O}_8\text{-PuO}_2$ powder.
- o Vaporize any waxes, binders or oils present in the MO_2 .
- o Produce an oxidized MO_2 powder which is capable of producing ceramic grade MO_2 .

1.2.3 Scrap Reduction

- o Convert the MO_x to a stabilized MO_2 at the required rate, temperature and atmosphere.
- o Produce a MO_2 powder which meets the main fabrication line powder specifications for scrap recovery powder.
- o Establish a uniform powder particle size distribution in the product powder.
- o Fill and weigh product storage containers.

- o Perform necessary transactions to allow transfer of the filled product container to storage.

1.3.0 Wet Scrap Recovery

1.3.1 Feed Preparation

1.3.1.1 Scrap Receipt

- o Receive incoming scrap feed and provide temporary storage.
- o Verify container identification.
- o Verify accountability weight of incoming container and container contents.
- o Verify container contents.

1.3.1.2 Oxidation Furnace Charge Make-Up

- o Reduce average particle size of feed material.
- o Segregate and recycle oversized material.
- o Weigh crushed product and load into furnace boats.
- o Provide temporary storage for oxidation furnace scrap feed.

1.3.1.3 Scrap Oxidation

- o Verify incoming container identification
- o Verify contents of incoming containers.
- o Oxidize MO_2 to a U_3O_8 - PuO_2 powder.
- o Vaporize any waxes, binders or oils present.
- o Increase surface area of the MO_x particles.

- o Provide accountability weight of outgoing MO_x .
- o Dump MO_x from boats into dissolution charge make-up feed hopper.
- o Recycle empty boats to the feed end of the furnace.

1.3.1.4 Dissolver Charge Make-Up

- o Remove oversized material from incoming MO_x and recycle it to the oxidation furnace.
- o Fill "product" containers with MO_x to a prescribed weight or level.
- o Provide accountability weight of product containers.
- o Provide temporary storage for "product" containers.

1.3.1.5 Dissolve Scrap

- o Dissolve all incoming MO_x in boiling nitric acid.
- o Maintain solids and nitric acid feed rates and temperature to produce a mixed nitrate with a constant heavy metal ratio and excess acid concentration.
- o Transfer product mixed nitrate liquid to the filters.

1.3.1.6 Filter Mixed Nitrate Liquid

- o Remove insolubles present in the mixed nitrate stream.
- o Regenerate filter media and remove collected sludge.

1.3.1.7 Concentrate Mixed Nitrate Liquid

- o Concentrate the uranium and plutonium and reduce the excess nitric acid concentration present in the mixed nitrate stream to those levels desirable for processing through the solvent extraction system.
- o Maintain flow rates, volume additions and temperature to produce a mixed nitrate with a constant heavy metal ratio and excess acid concentration.
- o Transfer product mixed nitrate liquid to pH adjustment.

1.3.1.8 Adjust Mixed Nitrate pH

- o Adjust pH to a level desirable for processing through solvent extraction.
- o Maintain flow rates and volume additions to produce a mixed nitrate with a constant pH.
- o Provide capability for recirculation to produce a uniform liquid blend.
- o Transfer product mixed nitrate to the valence adjustment station.

1.3.1.9 Adjust Mixed Nitrate Valence

- o Adjust Pu^{+} content to a level desirable for processing through solvent extraction.
- o Maintain flow rates, levels, and volume additions to produce a mixed nitrate with a constant Pu^{+6} content.

- o Provide capability for recirculation to produce a uniform liquid blend.
- o Transfer liquid product to the adjusted mixed nitrate storage.
- o Transfer product mixed nitrate to the valence adjustment station.

1.3.1.9 Adjust Mixed Nitrate Valence

- o Adjust Pu^{+} content to a level desirable for processing through solvent extraction.
- o Maintain flow rates, levels, and volume additions to produce a mixed nitrate with a constant Pu^{+6} content.
- o Provide capability for recirculation to produce a uniform liquid blend.
- o Transfer liquid product to the adjusted mixed nitrate storage.

1.3.2 Co-Purification

1.3.2.1 Solvent Extraction

- o Co-process U/Pu to convert to a 30% Pu purified mixed nitrate solution in one pass.
- o Purify the stripped uranyl nitrate stream for ultimate blending and/or conversion to UO_2 in one pass.
- o Remove impurities such as Fe, Ni, Cr, Si, Ca, and Mo to within specification limits in one pass.

- o Purify the stripped uranyl nitrate stream for ultimate blending and/or conversion to UO_2 in one pass.
- o Remove impurities such as Fe, Ni, Cr, Si, Ca, and Mo to within specification limits in one pass.
- o Transfer uranyl nitrate and mixed nitrate to the conversion process.

1.3.2.2 Concentrate Purified Mixed Nitrate/Uranyl Nitrate

- o Concentrate the U and Pu content to within limits necessary for co-precipitation.
- o Establish final excess nitric acid concentrations.
- o Maintain flow rates, volume additions and temperature to produce a mixed nitrate with a constant heavy metal ratio and excess acid concentration.
- o Transfer the product mixed nitrate liquid to co-conversion feed.

1.3.2.3 Store Co-Conversion Feed (Uranyl Nitrate and Mixed Nitrate)

- o Provide capability for recirculation to produce a uniform liquid blend.
- o Provide in-process storage for feed to co-conversion.
- o Provide accountability measurements.
- o Transfer liquid feed to co-conversion.

1.3.3 Co-Conversion

1.3.3.1 Precipitate Mixed Nitrate

- o Co-precipitate U and Pu under controlled conditions to produce a $\text{Pu}(\text{OH})_4/(\text{UO}_3)_2 \cdot \text{NH}_3 \cdot 5\text{H}_2\text{O}$ slurry.

- o Maintain flow rates, volume additions and tank levels to produce a slurry with a constant heavy metal ratio and solids content.
- o Transfer the precipitated slurry to the calciner at the proper flow rates.

1.3.3.2 Convert to MO_3 Powder

- o Convert the precipitated slurry to MO_3 powder at the required rate, temperature and atmosphere.
- o Collect powder from the offgas in a fixed container.
- o Provide accountability weight of the container and its contents.
- o Transfer powder to the reduction station.
- o Treat and remove condensables from the offgas stream.

1.3.3.3 Reduce to MO_2 Powder

- o Convert the MO_3 to MO_2 at the required rate, temperature and atmosphere.
- o Collect powder from the offgas in a fixed container.
- o Provide accountability weight of the product container and its contents.
- o Transfer product powder to the stabilization station.

1.3.3.4 Stabilize Product Powder

- o Produce a MO_{2+x} powder which is resistant to further oxidation.
- o Produce a MO_2 powder which meets the main fabrication line minimum ceramic requirements for wet scrap recovery powder.
- o Collect powder from the offgas in a fixed container.
- o Provide accountability weight of the product container and its contents.
- o Sample selected containers and send to the analytical laboratory for analyses.

1.3.3.5 Mill Product MO_2

- o Normalize powder particle size distribution.
- o Produce a MO_2 powder with uniform ceramic characteristics.
- o Separate and recycle oversized material from the product stream.
- o Provide accountability weight of the product.
- o Sample selected containers and transport samples to the analytical laboratory for analyses.
- o Transport the final product to product storage.

2.0 Equipment Criteria

The following general criteria apply to all equipment within the scrap recovery functional area:

- o Normal operation shall be performed in a fully remote mode.

- o Some "hands-on" maintenance may be performed on failed equipment after decontamination and removal from the processing gallery.
- o Equipment shall be designed with sufficient reliability to assure that the overall scrap recovery function will not impact on the main fabrication line greater than 0.5% of the main fabrication line availability.
- o All equipment shall be designed for criticality safety. Geometry control will be used whenever possible.
- o Use of sharp corners or cavities will be minimized to reduce powder/liquid holdup in the equipment during normal operation and during shutdown and cleanout conditions.
- o Equipment shall be easily disassembled and maintained under remote and/or glove box conditions.

3.0 Design Requirements

3.1 Process Requirements

3.1.1 Process Line Capacity

The combined wet and dry scrap recovery processes shall be capable of an instantaneous production rate of 6 Kg HM/hr (based on a 320 day year). Wet scrap recovery shall have a minimum recovery rate of 3.5 Kg HM/hr.

3.1.2 Dry Scrap Recovery

3.1.2.1 Feed Preparation

The scrap receipt station shall receive scrap MO_2 which is scheduled for dry scrap recovery directly from the central vault. The scrap MO_2 shall consist of powder, green scrap, green pellets and sintered pellets segregated in storage containers as sintered or unsintered scrap. All scrap entering the area shall be identified by a unique identification number, type, isotopic content and net weight.

Upon receipt in Scrap Recovery, the scrap container and its contents shall be checked to

verify container identification, gross, tare and net weights and container contents. If all verifications are positive, the scrap will be released to process and placed in in-process storage. If any verifications are negative the scrap container and its contents will be returned to the central vault for resolution.

After release to process, selected scrap containers will be moved from in-process storage to the crusher areas and the contents dumped to the crusher feeder. The container contents will be dumped in such a way that spillage or dusting or both will be controlled at $< 0.2\%$ of throughput. The scrap will be crushed and screened to assure that the final crushed product contains $> 95\%$ of -200 mesh particles. Oversized material will be segregated and recycled through the crusher. The crushed product will be collected in oxidation boats which contain up to 6.0 Kg HM. After filling, the boats will receive ID numbers, the necessary SNM transactions will be performed, and the filled boats will be placed in the oxidation furnace feed storage.

3.1.2.2 Scrap Oxidation

Oxidation furnace feed boats shall be moved from in-process storage to the furnace feed conveyor. Stoking of the boats into, through, and out of the oxidation furnace shall occur automatically.

The furnace shall be capable of continuous operation in an oxidizing atmosphere at temperatures in the $800-1000^{\circ}\text{C}$ range, with the maximum temperature not expected to exceed 1500°C . The MO_2 powder and pellets shall be oxidized to a $\text{U}_3\text{O}_8\text{-PuO}_2$ powder.

The furnace stoke rate and the residence time in the hot zone shall be established to allow the MO_{2+x} to be produced at the required rate. This may necessitate the use of more than one oxidation furnace. It is anticipated that the furnace shall be electrically heated.

The furnace airlocks and loading and unloading areas shall be of stainless steel construction. The furnace shell shall be fabricated of stainless steel.

The furnace refractory system shall be designed such that a surface temperature of $<75^{\circ}\text{C}$ is maintained. The cooldown portion of the furnace shall be air or water cooled such that boats enter the exit airlock at not more than 50°C .

The furnace offgas shall be equipped with a recirculating scrubber and demister system to both cool and remove particulates and condensables from the offgas stream.

Spent scrubber solution will periodically be sent to liquid waste treatment for ultimate disposal. Beyond the scrubber it is anticipated that the offgas will pass through both a demister and absolute filters before entering the primary ventilation system.

Upon completion of the oxidation cycle, the furnace boats and their contents shall be placed on the reduction furnace feed conveyor.

3.1.2.3 Scrap Reduction

Stoking of the furnace boats into, through and out of the reduction furnace shall occur automatically.

The reduction furnace shall be close-coupled with the calciner and shall be capable of semi-continuous operation in a 6% H_2 , 94% N_2 atmosphere to achieve reduction and stabilization with CO_2 .

The furnace(s) shall normally operate in the $400\text{--}800^{\circ}\text{C}$ range, with the maximum temperature not expected to exceed 900°C . The MO_{2+x} powder shall be reduced to MO_2 powder with ceramic attributes equal to or better than those required for material incoming to the fabrication line. To meet the required instantaneous production rate, more than one furnace may be required.

The furnace and its components shall be of stainless steel construction.

The furnace refractory system shall be designed such that no air or water cooling is required to maintain a surface temperature of 75°C . The cooldown portion of the furnace shall be air or water cooled such that product leaves the furnace at not more than 50°C .

The furnace offgas shall be equipped with a recirculating scrubber and demister system to both cool and remove particulates and condensables from the offgas stream.

Spent scrubber solution will periodically be sent to liquid waste treatment for ultimate disposal. Beyond the scrubber it is anticipated that the offgas will pass through both a demister and absolute filters before entering the primary ventilation system.

After reduction is complete, samples will be pulled to assure that the O/M values of the MO_2 are within limits. The boat contents will be dumped into the mill feed hopper and the empty boats returned to empty boat storage in the oxidation furnace area.

The milling station shall be close-coupled with the reduction furnace and shall include an optional queuing area to be activated if the mill becomes inoperative. The MO_2 powder shall be automatically dumped into the mill hopper, fed through the mill and into a powder collector. The station shall be designed to limit dusting and spillage to $< 0.2\%$ of throughput.

The mill shall be a high energy type (hammermill, fluid energy mill or equivalent) and shall reduce the incoming powder to < 150 mesh. Powder from the mill shall be automatically fed into containers suitable for vault storage.

Prior to transfer to vault storage, powder shall be sampled for sinterability testing and other ceramic and chemical characterizations as required. Based upon test results, the powder shall be dispositioned from vault storage to the fabrication line, or returned to the Scrap Recovery for further processing.

3.1.3 Wet Scrap Recovery

3.1.3.1 Feed Preparation

3.1.3.1.1 Scrap Receipt and Crushing

The scrap receipt station shall receive scrap MO_2 which is scheduled for dry scrap recovery directly from the central vault. The scrap

MO₂ shall consist of powder, green scrap, green pellets, grinder swarf, and sintered pellets segregated in storage containers as sintered or unsintered scrap. All scrap entering the area shall be identified by a unique identification number, type, isotopic content and net weight.

Upon receipt in Scrap Recovery, the scrap container and its contents shall be checked to verify container identification, gross, tare and net weights and container contents. If all verifications are positive, the scrap will be released to process and placed in in-process storage. If any verifications are negative, the scrap container and its contents will be returned to the central vault for resolution.

After release to process, selected scrap containers will be moved from in-process storage to the crusher areas and the contents dumped to the contents will be dumped in such a way that spillage or dusting will be controlled at < 0.2% of throughput.

The scrap will be crushed and screened to assure that the final crushed product contains > 95% of -200 mesh particles. Oversized material will be segregated and recycled through the crusher. The crushed product will be collected in oxidation boats which contain up to 6.0 Kg HM. After filling, the boats will receive ID numbers, the necessary SNM transactions will be performed, and the filled boats will be placed in the oxidation furnace feed storage.

3.1.3.1.2 Scrap Oxidation

Oxidation furnace feed boats shall be moved from in-process storage to the furnace feed conveyor. Stoking of the boats into, through and out of the oxidation furnace shall occur automatically.

The furnace shall be capable of continuous operation in an oxidizing atmosphere at temperatures in the 800-1000°C range, with the maximum temperature not expected to exceed 1200°C. The MO_2 powder and pellets shall be oxidized to a $\text{U}_{308}\text{-PuO}_2$ powder containing < 20 mesh particles.

The furnace stoke rate and the residence time in the hot zone shall be established to allow the MO_{2+x} to be produced at the required rate. This may necessitate the use of more than one oxidation furnace. It is anticipated that the furnace(s) shall be electrically heated.

The furnace airlocks and loading and unloading areas shall be of stainless steel construction. The furnace shell shall be fabricated of stainless steel or of a steel material compatible with acid resistant paint.

The furnace refractory system shall be designed to maintain a surface temperature of 75°C. The cooldown portion of the furnace shall be air or water cooled such that boats enter the exit airlock at not more than 50°C.

The furnace offgas shall be equipped with a recirculating scrubber and demister system to both cool and remove particulates and condensables from the offgas stream.

Spent scrubber solution will periodically be sent to liquid waste treatment for ultimate disposal. Beyond the scrubber it is anticipated that the offgas will pass through both a demister and absolute filters before entering the primary ventilation system.

Upon completion of the oxidation cycle, the furnace boats and their contents shall be placed in the dissolver charge make-up area.

3.1.3.1.3 Dissolver Charge Make-Up

The charge make-up station shall be close-coupled with the oxidation furnace with an optional queuing capability available should the charge makeup or dissolution system become inoperative. The oxidized MO_x shall be automatically dumped through a vibratory screener containing a single 200 mesh screen. The screened product shall feed into vibratory feeders which will automatically weigh out a prescribed amount of material, load it into a container for dissolution and make the necessary computer transactions to allow transfer of the charges to the dissolvers. The oversized product shall be automatically fed into a separate vibratory feeder which will weigh 6.0 Kg batches into furnace boats to allow recycle to the oxidation furnace. Gross impurities such as bolts, nuts, etc., shall be removed and transferred to solid waste treatment.

The charge make-up station shall be designed to limit spillage or dusting to $< 0.2\%$ of throughput.

3.1.3.1.4 Dissolve Scrap

The dissolution station may contain more than one dissolver. Each dissolver shall be equipped with a feeder to automatically feed the scrap into the dissolver. The dissolvers and all associated equipment shall be of stainless steel construction.

The scrap shall be fed by batches into a continuous dissolver containing boiling HNO_3 . The dissolver shall be designed to provide a 4-hour minimum holdup for scrap.

The mixed nitrate product exiting the dissolver will undergo continuous NDA to monitor the U and Pu content. The U and Pu content along with the mixed nitrate overflow rate shall be input to the process control computer which will automatically regulate the scrap feed rate and the nitric acid addition rate. The computer shall also use the U/Pu content, the mixed nitrate overflow rate and the scrap feed rate to perform a material balance around the dissolver and continuously monitor the scrap heel present. If the undissolved heel exceeds an as yet to be determined set point, the scrap feed will be halted until the heel falls below the prescribed limit.

Heat for the nitric acid shall be provided via steam jacket or steam injection and shall be capable of heating cold nitric acid to boiling within 30 minutes. The dissolver shall be sparged to promote acid/scrap contact.

The scrap feeding operation shall be designed to limit spillage or dusting to < 0.2% of throughput.

3.1.3.1.5 Filter Mixed Nitrate Liquid

All mixed nitrate leaving the dissolution station shall pass through filters to remove insolubles which contain greater than 10 micron particles.

The filter housing and filters shall be of stainless steel construction. To allow backflushing or filter change, it is anticipated that duplicate filters in parallel will be required.

The backflush system shall contain a sludge removal system which collects and consolidates the sludge.

3.1.3.1.6 Concentrate Mixed Nitrate Liquid

The feed concentrator shall be designed for batch or semi-continuous operation. The design of the concentrator shall reflect critically safe geometry considerations and may consist of multiple units. During startup, the heating system shall be capable of heating the mixed nitrate from room temperature to boiling, within one hour; during operation, the heating system must maintain a boil-off rate of at least 20 liters/hour. The external surface of the vessel or the furnace shall be designed to be $< 75^{\circ}\text{C}$.

A side-stream from each concentrator shall circulate continuously during operation through a NDA device which automatically determines U and Pu concentrations. The U and Pu concentrations will automatically be input to the process control computer and to a remote readout in the SRRS control room.

3.1.3.1.7 Acid and Valence Adjustment

The acid and valence adjustment station shall be designed to operate in either a batch or semi-continuous mode. The amount of dilute HNO_3 and H_2O_2 added shall be determined and controlled automatically by computer, based on the Pu^{+6} and excess acid content determined by the previous step. The station may require multiple tanks to accomplish the required adjustments. Each tank shall be capable of recirculation within itself or in other tanks to provide a uniform feed to solvent extraction.

Dilute HNO_3 and H_2O_2 head tanks shall be provided in containment, with primary storage tanks being

located out of box in a tank farm, where all process chemicals for the plant are stored.

3.1.3.2 Co-Purification

3.1.3.2.1 Solvent Extraction

The solvent extraction system shall be capable of removing impurities present in the mixed nitrate to within the impurity levels required for MO_2 in the fabrication line. The uranyl nitrate produced during the plutonium enrichment shall also limit impurities to within specification levels and shall be stored in a separate tank until it is processed through the COPRECAL conversion system.

The waste stream from the HA column shall contain less than 0.15% of input and shall be queued in a waste storage tank for NDA before shipment to Waste Treatment.

Spent organic shall be reclaimed for re-use via a Na_2CO_3 scrub. The spent Na_2CO_3 shall be queued in waste storage prior to shipment to waste treatment. Organic which can no longer be reclaimed shall be unloaded from the scrub column into containers and transported to Waste Treatment for disposal.

All tankage within the solvent extraction system shall be of stainless steel construction and designed to meet criticality control considerations.

3.1.3.2.2 Solvent Extraction Product Storage

The solvent extraction product storage shall consist of critically safe geometry pipe tanks which are manifolded together at the inlet and outlet. The station shall be capable of filling and emptying one tank at a time, or all tanks, simultaneously. The station shall also be capable of recirculating the contents of one tank individually or all tanks simultaneously. Each tank shall be designed to contain a sampling system which allows rapid turnaround time for analysis. The primary analyses to be performed on the product mixed nitrate at this station will be excess acid concentration and Pu^{+6} content.

3.1.3.2.3 Product Concentration

The product concentrator shall be designed for batch or semi-continuous operation. The design of the concentrator shall reflect critically safe geometry considerations and therefore, may require multiple units. The heating system shall be capable of heating the mixed nitrate from room temperature to boiling, during start-up, within one hour, and during operation, maintaining a boil-off rate of at least 100 liters/hour.

The external surface of the vessel or the furnace shall be designed to be $\leq 75^{\circ}\text{C}$.

A side-stream from each concentrator shall circulate continuously during operation through a NDA device which automatically determines U and Pu concentrations. The U and Pu concentrations will automatically be input to the process control computer and to a remote readout in the control room.

3.1.3.2.4 Concentrator Product Storage

The concentrator product storage station shall consist of several safe geometry, stainless steel tanks manifolded together at the inlets and outlets. The station shall be capable of receiving the concentrated nitrate, blending the nitrate and providing an 8 hour queue ahead of precipitation. Each tank shall be designed to include sample ports and recirculation capabilities.

Process control samples will be pulled on a once or twice per shift basis to check impurity content, U/Pu content, excess acid molarity and isotopic distribution.

3.1.3.3 Co-Conversion

3.1.3.3.1 Precipitate Mixed Nitrate

The precipitation station shall be designed to maintain the slurry precipitation pH as required for the best precipitation conditions. The mixed nitrate shall enter the station through the top of the tank to create a pool precipitation effect within the tank. The contents of the tank shall be continuously mixed by recirculation or paddle mixer to provide optimum precipitation conditions.

NH₄OH make-up addition and mixed nitrate addition shall be controlled automatically by the process computer.

3.1.3.3.2 Convert to MO₃ Powder

Calcination of the slurry shall be performed in a vertical, fluidized bed reactor using a 6% H₂/94% N₂ mixture. The calciner shall be designed for operation in the 500-800°C range, with a maximum temperature of 1000°C.

The calciner shall be operated using an inert bed and jet mill for particle removal from the bed. Slurry shall be introduced into the bed through the side of the reactor. The feed rate will be controlled by the computer which will be continually monitoring bed temperature, production rate, offgas filter differential pressure and bed differential pressure.

The elutriated powder and offgases shall be transported to the reduction vessel for conversion to MO_2 .

3.1.3.3.3 Reduce to MO_2 Powder

The reduction furnace shall be close-coupled with the calciner/powder collector and shall be capable of semi-continuous operation in a 6% H_2 -94% N_2 atmosphere to achieve reduction and stabilization with CO_2 .

The furnace(s) shall normally operate in the 400-800°C range, with the maximum temperature not expected to exceed 900°C. The MO_{2+x} powder shall be reduced to MO_2 powder with ceramic attributes equal to those required for material incoming to the fabrication line. To meet the required instantaneous production rate of 24 Kg MO_2 /hr, more than one furnace may be required.

The furnace and its components shall be of stainless steel construction or of a steel material compatible with acid resistant paint.

The furnace refractory system shall be designed such that no air or water cooling is required to maintain a surface temperature of 75°C. The cooldown portion of the furnace shall be air or water cooled such that product leaves the furnace at not more than 50°C.

The furnace offgas shall be equipped with a recirculating scrubber and demister system to both cool and remove particulates and condensables from the offgas stream.

Spent scrubber solution will periodically be sent to liquid waste treatment for ultimate disposal. Beyond the scrubber it is anticipated that the offgas will pass through both a demister and absolute filters before entering the primary ventilation system.

The stabilization furnace shall be close-coupled with the reduction furnace and shall be capable of semi-continuous operation in a CO₂ atmosphere to achieve stabilization.

The furnace(s) shall normally operate in the 400-800°C range, with the maximum temperature not expected to exceed 1000°C. The MO₂ shall be slightly reoxidized to MO_{2+x} such that the final product powder will be chemically stable with respect to further oxidation and will possess ceramic attributes equal to or better than those required for material incoming to the fabrication line. To meet the required instantaneous production rate more than one furnace may be required. The furnace and its components shall be of stainless steel construction or of a steel material compatible with acid resistant paint.

The furnace refractory system shall be designed such that no air or water cooling is required to maintain a surface temperature of 75°C. The cooldown portion of the furnace shall be air or water cooled such that product leaves the furnace at not more than 50°C.

The furnace offgas shall be equipped with a recirculating scrubber and demister system to both cool and remove particulates and condensables from the offgas stream.

Spent scrubber solution will periodically be sent to liquid waste treatment for ultimate disposal. Beyond the scrubber it is anticipated that the offgas will pass through both a demister and absolute filters before entering the primary ventilation system.

3.1.3.3.4 Mill Product MO_2

The milling station shall be close-coupled with the reduction furnace and with an optional queuing area should the mill become inoperative. The MO_2 powder shall be automatically dumped into the mill hopper, fed through the mill and into a powder collector.

The mill shall be a high energy type (hammermill, fluid energy mill or equivalent) and shall reduce the Powder from the mill shall be automatically fed into containers suitable for vault storage.

Prior to transfer to vault storage, powder shall be sampled for sinterability testing and other ceramic and chemical characterizations results, the powder shall be dis-positioned from vault storage to the fabrication line, or back to Scrap Recovery for further processing.

3.2 Structural Requirements

Structural design for scrap recovery shall be a part of the integrated facility design for the overall fuel refabrication plant and shall adhere to those overall requirements.

3.3 System Configuration and Essential Features

Scrap recovery shall be designed for fully remote operation. Both the facility and equipment shall be designed to be resistant to attack by nitric acid. Sources of process services, gases and chemicals shall be available as required for each station.

3.4 Maintenance

Maintenance shall be performed remotely and in-place whenever possible. That maintenance which cannot be performed in-place may be performed in a "hands-on" mode in a remote glove box after the equipment has been decontaminated and removed from the processing gallery. In order to minimize personnel exposure during maintenance, equipment shall be designed and selected to provide:

- o minimum holdup when run "dry"
- o ease of disassembly and maintenance
- o high reliability to reduce frequency of maintenance
- o minimum use of sharp corners and cavities to reduce material accumulation and holdup

In case of major equipment failure, each piece of process equipment shall be capable of being easily removed from the process and readily replaced with minimum downtime.

3.5 Surveillance and In-Source Installation

Surveillance systems shall be implemented to satisfy all federal, state and SAF requirements concerning personnel exposure, accountability control, SNM safeguards, radiation release to the environment, safety, etc. These systems will be designed, installed and maintained by the facilities function.

3.6 Instrumentation and Control

The following instrumentation shall be provided for monitoring the stations indicated:

3.6.1 General

The necessary instrumentation and control systems for accountability, criticality and fire detection, radiation exposure, ventilation monitoring and personnel safety shall be provided and maintained by the facilities function and are not included in this SDD.

3.6.2 Dry Scrap Recovery

3.6.2.1 Feed Preparation

- o accountability weight of material received from vault storage
- o voltage and amperage of the crusher
- o accountability weight of material loaded into each boat

3.6.2.2 Scrap Oxidation

- o control of furnace temperature by zone
- o control of furnace gas flows
- o control of voltage and amperage by zone
- o control of boat position with respect to time and identification of boats in the boat transfer system
- o control of furnace cooling system temperature

3.6.2.3 Scrap Reduction

- o control of furnace temperature by zone
- o control of furnace gas flows
- o control of voltage and amperage by zone
- o control of boat position with respect to time and identification of boats in the boat transfer system
- o control of furnace cooling system temperature
- o accountability weight of powder removed
- o mill pressure monitoring

3.6.3 Wet Scrap Recovery

3.6.3.1 Feed Preparation

3.6.3.1.1 Scrap Receipt

- o accountability weight of material received from storage vault

3.6.3.1.2 Oxidation Furnace Charge Make-Up

- o voltage and amperage of crusher
- o accountability weight of material loaded into each boat.

3.6.3.1.3 Scrap Oxidation

- o control of furnace temperature by zone
- o control of furnace gas flows
- o control of voltage and amperage by zone
- o control of boat position with respect to time and identification of boats in the boat transfer system
- o control of furnace cooling system temperature

3.6.3.1.4 Dissolver Charge Make-Up

- o accountability weight of material

3.6.3.1.5 Dissolve Scrap

- o continuous NDA for Pu and U content of product stream
- o flow control of product stream
- o flow control of nitric acid addition

- o temperature control of acid dissolution bath
- o continuous NDA for U and Pu in off-gas scrubber liquid
- o sparge gas flow control
- o continuous readout of NO_x content in offgas beyond scrubber
- o NO_x scrubber fluid flow control
- o monitoring of free acid content of product stream

3.6.3.1.6 Filter Mixed Nitrate Liquid

- o filter differential pressure monitoring
- o filter housing pressure monitoring.

3.6.3.1.7 Concentrate Mixed Nitrate Liquid

- o continuous NDA for Pu and U content of concentrator solution
- o temperature control of concentrator bath
- o concentrator fluid level monitoring
- o coolant flow control to reflux column
- o coolant flow control to condenser
- o reflux column outlet temperature monitoring
- o condenser outlet temperature monitoring
- o condensate storage tank level monitoring

3.6.3.1.8 Acid and Valence Adjustment

- o control of HNO_3 added
- o control of H_2O_2 added
- o recirculation flow control

3.6.3.2 Co-Purification

3.6.3.2.1 Solvent Extraction

- o continuous NDA for Pu and U content of product.
- o flow control of incoming material
- o flow control of make-up solvent
- o flow control of circulating solvent
- o flow control of product stream
- o continuous NDA for U/Pu content of waste stream

3.6.3.2.2 Solvent Extraction Product Storage.

- o recirculation flow control
- o tank level monitoring
- o product entry and withdrawal flow control

3.6.3.2.3 Product Concentration

- o continuous NDA for Pu and U content of concentrator solution
- o temperature control of concentrator bath

- o concentrator fluid level monitoring
- o coolant flow control to reflux column
- o coolant flow control to condenser

3.6.3.2 Co-Purification

3.6.3.2.1 Solvent Extraction

- o continuous NDA for Pu and U content of product.
- o flow control of incoming material
- o flow control of make-up solvent
- o flow control of circulating solvent
- o flow control of product stream
- o continuous NDA for U/Pu content of waste stream

3.6.3.2.2 Solvent Extraction Product Storage.

- o recirculation flow control
- o tank level monitoring
- o product entry and withdrawal flow control

3.6.3.2.3 Product Concentration

- o continuous NDA for Pu and U content of concentrator solution
- o temperature control of concentrator bath
- o concentrator fluid level monitoring
- o coolant flow control to reflux column

- o coolant flow control to condenser
- o reflux column outlet temperature monitoring
- o condenser outlet temperature monitoring
- o condensate storage tank level monitoring
- o concentrator fluid level monitoring
- o scrubber fluid flow control
- o continuous measure of excess nitric acid content of product

3.6.3.2.4 Concentrator Product Storage

- o recirculation flow control
- o tank level monitoring
- o product entry and withdrawal from control

3.6.3.3 Co-Conversion

3.6.3.3.1 Precipitation

- o NH_4OH make-up addition flow control
- o mixed nitrate addition flow control
- o precipitation bath pH monitoring
- o precipitation bath temperature monitoring

3.6.3.3.2 Calcination

- o temperature control of fluidized bed
- o slurry feed control
- o bed differential pressure monitoring
- o calciner system pressure monitoring
- o off-gas filter differential pressure monitoring
- o condenser coolant flow control
- o condenser outlet temperature monitoring
- o process gas flow control
- o condensate storage tank level monitoring
- o weight of product powder removed

3.6.3.3.3 Reduction

- o temperature control of reduction bed
- o flow control of process gases
- o offgas filter differential pressure
- o reduction vessel pressure monitoring

3.6.3.3.4 Stabilization

- o temperature control of reduction bed
- o flow control of process gases
- o offgas filter differential pressure
- o reduction vessel pressure monitoring

3.6.3.3.5 Milling

- o weight of product powder removed
- o mill pressure monitoring

3.7 Interfacing Systems

The following functions and services shall be provided by interfacing systems:

Material handling between stations in the following sequence:

- o transfer of powder and pellets from central storage to charge make-up
- o transfer of empty boats to charge make-up
- o recycle of oversized material from dissolution charge make-up to the oxidation furnace
- o transfer of charges from dissolution charge make-up to the dissolution tanks
- o transfer of liquid wastes (spent organics and aqueous wastes) from queuing tanks
- o transfer of powder from the reduction area to the mill
- o transfer of powder from the mill to central storage
- o transfer of required liquid and powder samples to the laboratory

Facilities and Support will be responsible for providing and maintaining the following services:

- o HVAC for all cells, glove boxes and process offgas
- o all process chemicals which include:
 - o concentrated HNO_3
 - o dilute HNO_3
 - o Tri Butyl Phosphate
 - o Na_2CO_3
 - o H_2O_2
 - o NH_4OH
 - o mixed gas (6% H_2 /94% N_2)
 - o N_2
 - o CO_2
 - o electrical power
 - o instrument and compressed air
 - o vacuum/vent systems
 - o cooling air and water
- o Analytical Laboratory
 - o Rapid turnaround time for the following analyses:
 - o metal impurities
 - o ceramic characterization
 - o free acid content
 - o percent plutonium
 - o O/M
 - o Pu^{+6} content
 - o isotopic distribution

- o Accountability
 - o uranium and plutonium content in liquid, organic and solid waste streams.
 - o material balance capability around each process station and the Scrap Recovery as a whole.
 - o overcheck capabilities for in-line NDA.
- o NDA
 - o in-line monitoring of all liquid streams continuously for process and accountability control
 - o monitor all product produced by Scrap Recovery prior to transfer back to the vault
 - o monitor all solid waste produced prior to transfer out of the Scrap Recovery MBA

3.8 Production and Quality Control

3.8.1 General

A calibration system shall be established for all instrumentation used for process or quality control.

3.8.2 Charge Make-up

No special production or quality control requirements other than material weighing for accountability.

3.8.3 Oxidation-Furnace

No special production or quality control requirements other than material weighing for accountability.

3.8.4 Dissolution Charge Makeup

No special production or quality control requirements other than material weighing for accountability and for check of distribution between accept and reject fractions to verify screen integrity.

3.8.5 Dissolution

Equipment shall be provided for continuous NDA for Pu and U content of the product solution.

3.8.6 Filtration

No special production or quality control requirements.

3.8.7 Concentration

- o continuous NDA for Pu and U content of concentrator solution
- o temperature control of concentrator bath
- o concentrator fluid level monitoring
- o coolant flow control to reflux column
- o coolant flow control to condenser
- o reflux column outlet temperature monitoring
- o condenser outlet temperature monitoring
- o condensate storage tank level monitoring
- o concentrator fluid level monitoring
- o scrubber fluid flow control
- o continuous measure of excess nitric acid content of product

3.8.8 Acid and Valence Adjustment

No special production or quality control requirements

3.8.9 Solvent Extraction

Equipment shall be provided for continuous NDA for Pu and U content of the product solution and waste stream.

3.8.10 Solvent Extraction Product Storage

Rapid-turnaround analytical laboratory capabilities shall be provided for determination of:

- o excess acid concentration
- o Pu⁺⁶ content
- o impurities content

3.8.11 Product Concentration

Equipment shall be provided for continuous NDA for Pu and U content of the concentrator solution.

3.8.12 Concentrator Product Storage

Rapid turnaround analytical laboratory capabilities shall be provided for determination of:

- o impurity content
- o U and Pu content
- o excess acid molarity
- o isotopic distribution

3.8.13 Precipitation

Equipment shall be provided for continuous monitoring of metal nitrate and NH_4OH stream.

3.8.14 Calcination

Temperature monitoring

3.8.15 Reduction and Stabilization

Rapid turnaround analytical laboratory capabilities shall be provided for determination of characteristics required for certification of material for return to the fabrication line including:

- o oxygen-to-metal ratio
- o impurity content
- o particle size distribution
- o sinterability test results
- o U and Pu content
- o isotopic distribution

3.8.16 Milling

No special production or accountability control requirement other than material weighing for accountability.

3.9 Reliability Assurance

In order to provide assurance that the process line will remain operational, the need for off-line backup units for each process step must be assessed. If implemented, equipment handling systems shall be included for transfer from an inoperative station to the off-line station as needed.

3.10 Design Safety Requirements

Standard safety design procedures shall be followed for all cell design. Equipment outside the containment shall be provided with personnel protection barriers as required. Criticality control shall be provided for all process equipment by geometry or double batch size limits based on 30 percent Pu in all equipment. Due to physical barriers, feed hoppers for depleted UO₂ and non-SNM constituents need not be criticality controlled.

3.11 Radiation Shielding Requirements

All continuously occupied work areas shall be limited to < 0.5 mrem/hour. Areas limited to intermittent occupancy shall not exceed 5 mrem/hour. A decontamination/maintenance glove box shall be provided for equipment which must be removed for repair. Radiation exposure shall be minimized by removal of SNM from and cleaning of equipment prior to "hands-on" maintenance.

3.12 Safeguards Considerations

The Scrap Recovery function shall be operated on a moving inventory basis. Monitoring systems shall be provided for measurement of ID and LEID. Building design shall include safeguards consideration. In-line retention of SNM shall be minimized and vault storage shall be utilized wherever possible.