11.0 PLANT SYSTEMS
11.8 FLUID TRANSPORT SYSTEMS

11.8.1 CONDUCT OF REVIEW

This chapter of the draft Safety Evaluation Report (DSER) contains the staff's review of the fluid transport systems described by the applicant in Chapter 11.0 of the Construction Authorization Request (CAR). The objective of this review is to determine whether the fluid transport principal structures, systems, and components (PSSCs) and their design bases identified by the applicant provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. The staff evaluated the information provided by the applicant for fluid transport systems by reviewing Chapter 11.0 of the CAR, other sections of the CAR, supplementary information provided by the applicant, and relevant documents available at the applicant's offices but not submitted by the applicant. Additional documentation from the literature was reviewed as necessary to understand the process and safety requirements. The review of fluid transport systems design bases and strategies was closely coordinated with the review of fire protection in Section 7.0 of this DSER, the review of chemical safety in Section 8.0 of this DSER and the review of accident sequences described in the Safety Assessment of the Design Bases (see Chapter 5.0 of this DSER).

The staff reviewed how the information in the CAR addresses the following regulations:

- Section 70.23(b) 10 CFR requires that the design bases of the PSSCs and the quality assurance program must provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents before construction of the principal structures, systems and components is approved.

- Section 70.64 10 CFR requires that baseline design criteria (BDC) and defense-in-depth practices be incorporated into the design of new facilities. It specifically addresses quality standards; natural phenomena hazards; fire protection; environmental conditions and dynamic effects; emergency capability; inspection, testing and maintenance; criticality control; and instrumentation and controls.

The review for this construction approval focused on the design bases of fluid transport systems, their components, and other related information. For fluid transport systems, the staff reviewed and evaluated information provided by the applicant for the safety function, system description, and safety analysis. The review also encompassed proposed design basis considerations such as redundancy, independence, reliability, and quality. The staff used Chapter 11.0 in NUREG-1718, particularly Section 11.4.7, Material Transport System (Pumps and Valves), and industry codes and standards as guidance in performing the review.

The Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) fluid transport systems include systems that handle process and utility fluids. Other fluid-containing support systems are discussed in Section 11.9.

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the CAR submitted by the applicant for the following areas applicable to the fluid transport systems at the construction approval stage and consistent with the level of design:

- System description,

- System function.
- Major components.
- Control concepts.
- System interfaces.
- Design bases.

NUREG-1718, Section 11.4.7, “Material Transport System (Pumps and Valves),” was the primary guidance used for this review. Regarding the proposed MFFF fluid transport systems, specific design considerations given in the CAR should demonstrate the following:

- Adequate capacity to handle expected volume of radioactive material during normal operating and accident conditions.

- Redundancy or diversity of components required to prevent the release of radioactive materials to the environment or needed for safe operation of the material transport system.

- That the fluid transport system can be safety shutdown during normal and accident conditions. Provisions for emergency power are included for critical process components.

- Tank and piping systems are of welded construction to the fullest extent possible.

- Tank and piping systems are designed to take advantage of gravity flow to reduce the potential for contamination associated with pumping and pressurization.

- Criticality will not occur under normal and credible accident conditions.

- All system components expected to be in contact with strong acids or caustics are corrosion resistant.

- Piping is designed to minimize entrapment and buildup of solids in the system.

- That the systems are evaluated to determine the need for hoods, gloveboxes, and shielding for personnel protection. Generally, wet processing operations involving gram quantities of plutonium and any operations involving 50 micrograms of respirable plutonium are conducted in a glovebox.

- Surface finishes of materials in the work areas have satisfactory decontamination characteristics for their particular application.

- Fluid transport systems maintain functionality when subjected to tornadoes, tornado missiles, earthquakes, floods, and any other natural phenomena deemed to be credible as further established in the integrated safety assessment (ISA) to be performed by the applicant.

As stated in the 10 CFR Part 70 Subpart H rulemaking, IROFS may be described at the systems level, provided that there is enough detail to understand the function of the system in relation to the performance requirements. Accordingly, as discussed in DSER below, the staff finds it acceptable to identify PSSCs at the systems level, provided that there is enough detail to understand the function of the system in relation to the performance requirements.

In the DSER discussions that follow, the system descriptions are provided as well as function, major components, control concepts, and system interfaces. These discussions include, but are not limited to, PSSCs, to provide an understanding of the system.   Design bases of PSSCs are provided in Section 11.8.1.3.

11.8.1.1 System Description

The fluid transport systems are the hardware portion of the AP “wet” process that contains the dissolution unit, the purification cycle, silver and solvent recovery, oxalic precipitation, and precipitation and drying for the various stages of plutonium polishing. All wastes generated are stored and sent to by pipeline to the DOE Savannah River site for disposition.

In general, the fluid transport system consists of components that contain radioactive process fluids, radioactive waste products, and utility fluids. Principal SSCs in the process equipment include vessels, tanks, pulsed columns, heat exchangers, pumps, piping, and valves. Other process equipment includes electrolyzers, airlifts, drip pots, sampling lines and pots, spargers, gravity feeds, dosing wheels, magnetic stirrers, extraction screws, and stationary and rotary filters.

Fluid transport components are designed for the most severe credible service conditions. Fluids containing radioactive materials are designed to always be within at least two levels of containment according to the general principles described in CAR Section 11.4 and reviewed in this SAR. Fluid bearing components within process cells that are not easily accessed for routine inspection should be designed with corrosion allowances and provided with drip trays sized to hold the contents of the largest vessel in a critically safe condition. Sump pumps on the drip trays are monitored for activity signaling a leak. The system is designed to accommodate flushing and high-pressure decontamination to remove sediment buildup and any blockages and to maintain ALARA principles, prior to system maintenance.

The fluid transport systems for the AP process are include the normal, protective, and safety control subsystems. The normal control subsystem controls the MFFF manufacturing and processing operations. The protective control subsystem provides protection for equipment and personnel. The safety control subsystem is designed to ensure that safety limits will not be exceeded and that undesired operational conditions or events will not occur or will be properly mitigated. For more information on the AP process refer to Section 11.3 of this SER. Refer to Section 11.6 of this SER for more details on the design and operation of the instrumentation and control system.

As indicated above, the fluid transport system is diverse in the control concepts for the process control systems that govern the fluid transport systems. The AP process control systems are designed to ensure that the product of the manufacturing process will conform to the product specifications with minimal waste and risk. They are composed of the normal, protective, and safety control subsystems. The normal control subsystem controls the MFFF normal manufacturing and processing operations. The protective control subsystem provides protection for personnel and equipment. The safety control subsystem is designed to ensure that safety limits will not be exceeded and that undesired operational conditions or events will not occur or will be mitigated.

Fluid transport components are hydraulically designed for the most severe service conditions. Radiological fluids are maintained within at least two levels of confinement. Drip trays are provided in process cells. Vessels that contain radiological fluids are mounted over drip trays to collect leakage. The drip tray is designed to hold the contents of the largest vessel in a critically safe configuration as appropriate. Each drip tray contains a sump that is monitored for activity indicative of leakage.

Fluid transfer systems containing hazardous fluids are contained within trenches, rooms, or double-walled piping systems or are accessible for inspection and are of a fully welded construction. All piping components designated as IROFS are designed to withstand the design basis earthquake loads. Check valves may be of the following types: butterfly, gate, plug, or ball. The valves are specified for service after consideration of the chemical characteristics of the fluid, piping material of construction, and operating conditions.

The SRP, Section 11.8, used for the review of the fluid transport systems specifically mentions tank and piping systems be of welded construction to the fullest extent possible. For process equipment, radiological fluids are maintained within at least two levels of confinement. Components containing fluids that are located in process cells are specified with corrosion allowances and welded joints are radiographed, as appropriate. Fluid transfer systems containing hazardous fluids are contained within trenches, rooms, or double-walled piping systems or are accessible for inspection and are of a fully welded construction. Components that are not of fully welded construction are installed in a glovebox. Piping components carrying radiological fluids between two confinements are either fully-welded double wall construction or are installed in gloveboxes. Welding requirements are contained in the ASME B&PV Code, Section VIII, 1995 Edition through the 1996 Addenda, ASME B31.3, and their referenced American Welding Society Codes. Welding work will be performed according to the FTS category (see DSER Table 11.8.0) and quality assurance plan quality level of the system being welded.

Materials used for the construction of this equipment are specified in accordance with ASME and ASTM material specifications. ASME materials are used in the fabrication of equipment and piping components built to the requirements of ASME B&PV Code, Section VIII, Rules for Construction of Division 1 Pressure Vessels, 1995 Edition through the 1996 Addenda, and ASME B31.3, Process Piping code. ASTM materials are also used for the fabrication of other components. In general design of equipment to these standards means that the components are designed for the most severe service conditions. Included in the severe service conditions are pressure, temperature, stress, material compatibility, and corrosion.

11.8.1.1.1 Function

The AP process can be segmented into the following four operational areas:

- Plutonium purification process - Includes the Decanning Unit, Dissolution Unit, Purification Cycle, Oxalic Precipitation and Oxidation Unit, Homogenization Unit, and Canning Unit.

- Recovery processes - Includes the Solvent Recovery Cycle, Oxalic Mother Liquor Recovery Unit, Acid Recovery Unit, and Silver Recovery Unit.

- Waste storage - Includes the Liquid Waste Reception Unit.

- Offgas treatment - Includes the Offgas Treatment Unit.

This section will concentrate on the MOX equipment located in the plutonium purification process. The plutonium purification process separates impurities from the fissile material. This process is a radiochemical process where the fissile material co-mingles with inorganic and organic solutions at various concentrations. The plutonium purification process is divided into six discrete steps:

1. Decanning Unit - This is a mechanical operating unit where can opening and powder transfer operations are automatically performed, primarily in gloveboxes.

2. Dissolution Unit - PuO_2 from the Decanning Unit is electrochemically dissolved with silver (Ag 2+) in nitric acid. The plutonium valence of the resulting plutonium nitrate solution is altered by hydrogen peroxide from (VI) to (IV). The plutonium nitrate solution is transferred to the Purification Cycle feed tank.

3. Purification Cycle - The plutonium-nitrate solution from the Dissolution Unit is extracted into the organic phase from impurities (e.g., gallium, americium) in the flux. The organic stream is scrubbed with dilute nitric acid, its valence is further reduced to Pu(III), and it is stripped back into the aqueous solution. The plutonium nitrate is oxidized to the tetravalent state by NOx fumes.

4. Oxalic Precipitation and Oxidation Unit - Plutonium is precipitated with excess oxalic acid in vortex precipitators.

5. Homogenization Unit - The plutonium oxalate precipitate and the mother liquors flow from the precipitator and are channeled to a flat filter where they are filtered, washed, and vacuum-dewatered. The oxalate is dried and calcined.

6. Canning Unit - This mechanical operating unit is where the calcined PuO_2 is sampled and packaged for use in the MP process.

The balance of these steps are described and evaluated in detail in Section 8.0, “Chemical Safety,” and Section 11.3, “MP Process,” of this SRP.

11.8.1.1.2 Major Components

The major components of the fluid transport systems are part of the primary process and are located in the AP area of the MFFF. The major components of the fluid transport systems include: (1) Welded process equipment such as vessels, tanks, process columns, heat exchangers. In general, fully welded process equipment is located in process cells. Storage tanks vary in design at different stages of the primary process. Storage tanks include annular tanks, stab tanks, and conventional tanks. These tanks are fabricated using fully welded construction. Other welded process equipment includes various small tanks used in the AP process, such as separating pots, leak detection pots, barometric seal pots, pulse column pots, drip pots, condensate pots, and demisters. The AP process columns are also of a fully welded construction. Examples of these columns are pulsed, rectification, packed or scrubbing columns, and tray columns for process distillation. Various AP process heat exchangers used in radiological service are also of a fully welded construction. These heat exchangers may be evaporators, condensers, and jacketed heaters/coolers designed to transfer process heat; (2) partially welded process equipment and prime movers. This equipment includes filters, mixing tanks, and precipitators. Partially welded equipment classified as fluid transport system (FTS)

Category 1 is housed inside gloveboxes (see DSER Section 15.1 for a more detailed discussion). Other process prime movers include pumps, low-pressure airlifts, ejectors, and siphons. Pump types include centrifugal and positive displacement dosing pumps; and 3) piping and valves.

11.8.1.1.3 Control Concept

The AP process control systems are designed to ensure that the product of the manufacturing process will conform to the product specifications while simultaneously minimizing risk to the facility worker, site worker and public. They are composed of the normal, protective, and safety control subsystems. The normal control subsystem controls the MFFF normal manufacturing and processing operations. The protective control subsystem provides protection for personnel and equipment. The safety control subsystem is designed to ensure that safety limits will not be exceeded and that undesired operational conditions or events will not occur or will be mitigated. Section 11.6 of the CAR discusses the MFFF instrumentation and control systems in more detail.

In general, each unit is controlled by one or several programmable logic controllers (PLCs) associated with a monitoring workstation located in the AP control room. All units are operated in an automatic mode. The operator may also intercede via a manual mode in which the interlocks are active in case of trouble in the automatic mode or for maintenance operations. The Manufacturing Management Information System (MMIS) collects the information coming from all process units to control the position and the exchange of special nuclear material (SNM) as well as the traceability and the quality of the products.

Process storage and operation conditions are controlled to prevent exothermic and potential autocatalytic reactions in the AP Area. Autocatalytic and exothermic reactions of chemicals, precipitation, and criticality are prevented through control of the process parameters (e.g., reactant concentration, temperature, catalyst concentration in solution, and pressure) that affect the reactions.

11.8.1.2 System Interfaces

The individual systems that interface with the fluid transport systems include the following types of systems as described in the MFFF CAR Section 11.9, “Fluid Systems,” mechanical utility systems, bulk gas system, and reagent systems.

The mechanical utility systems that interface with the fluid transports systems include: the process chilled water system, the demineralized water system, the process hot water system, the process steam and condensate systems, the instrument air system. The bulk gas systems that interface with the fluid transport systems include: the nitrogen system, the argon/helium system, the helium system, and the oxygen system. The reagent systems that interface with the fluid transport system include the nitric acid system, the silver nitrate system, the tributyl phosphate system, the hydroxylamine system, the sodium hydroxide system, the oxyalic acid system, the diluent system, the sodium carbonate system, the hydrogen peroxide system, the hydrazine system, the manganese nitrate system, decontamination system, and the nitrogen oxide system.

11.8.1.3 Design Bases of PSSCs

This section describes the design basis commitments made by DCS and the defense-in-depth requirements of 10 CFR 70.64(b) for PSSCs. Defense-in-depth is discussed in Section 5 of this DSER.

DCS has identified design bases for principal SSCs applicable to the proposed MOX FFF fluid transport systems, as follows:

- Principal SSCs in the fluid transport system are designed to have adequate capacity to handle volume of radioactive materials during normal operation and design basis accident conditions
- Principal SSCs in the fluid transport system are designed to prevent the release of radioactive materials to the environment
- Principal SSCs in the fluid transport system are designed with isolation and shutdown provisions during normal operation and design basis accident conditions
- Materials used in the fabrication of Principal SSCs in the fluid transport system in severe environments, such as acidic or caustic contact, are selected to have suitable corrosion resistance characteristics
- Fluid transport systems are designed to minimize the potential for entrapment and buildup of radioactive materials
- Process equipment is designed to handle fissile material in accordance with radiation safety principles

General design bases for the fluid transport systems include:

- FTS components are laid out in a room to permit egress, evacuation, and material movement
- Passageways have adequate space for movement, repair, installation, and removal of proposed or anticipated equipment. Ergonomic factors are considered in the selection and placement of equipment and components
- Piping is centralized in dedicated galleries to the extent practical
- Components' design basis is defined from thermal and hydraulic calculations and will consider the physical and chemical properties of the process fluid
- Components handling radiological fluids are designed to use welded construction to the fullest extent practical when located in process cells. Components that are not of fully welded construction are installed in a glovebox
- Piping components carrying radiological fluids between two confinements are either fully welded double wall construction or are installed in gloveboxes
- FTS components are designed to withstand the design basis earthquake
- The building housing the FTS components involved in radiological processes will be designed for resistance to natural phenomena and industrial accidents

In the response to NRC's RAI, dated August 31, 2001, DCS provided specific engineering design criteria for the fluid transport system. This specific design criteria is given in DSER Table 11.8.5. In the remainder of this DSER section, the above-referenced PSSCs and general design bases for the fluid transport systems identified by DCS are evaluated.

This section describes the specific design bases for the fluid transport systems:

Hydraulic seals are used to prevent backflow of process fluid to auxiliary systems during reagent addition. The liquid seal or “plug” is maintained by the piping configuration. The seal is implemented by a “U” bend in piping or by hydraulic seal pots. The hydraulic seal design ensures that the seal remains filled with liquid at all times, the seal withstands internal pressure differences between connected vessels, and that siphon action does not occur.

Check valves are used only in process fluid pressure boundary. The check valve design basis is based on valve effective pressure drop, type of seating material, pressure and flow reversal response time, mounting requirements, and reliability and maintainability. Redundant seismic isolation valves, that are PSSCs, are used to automatically isolate utility and reagent fluids in the process area when earthquake conditions are detected. The isolation valves close in the event of valve or actuator failure. These valves are designed to prevent uncontrolled flooding of the BMF building as a result of a seismic event. The safety function of the isolation valves is to maintain safe isolation between controlled areas and uncontrolled areas that may contain radioactive materials.

The FTS categorization was established by DCS to describe the combination of component and material codes, seismic categories, and quality levels. These categories are summarized in Table 11.8.0. Tables 11.8.1 through 11.8.4, list the design codes and standards that will apply to each of the FTS Categories listed in Table 11.8.0.

Table 11.8.0, Categorization of the Fluid Transport System

FTS Category.	Description of Components in the Category
Category 1	Includes components that are PSSCs that contain process fluids with significant quantities of plutonium or americium. See Table 11.8.1 for applicable codes and standards. The application of the specific criteria for the material, fabrication, examination, testing, and installation were derived from applicable codes and standards and augmented by operating experience at the French La Hague facility.
Category 2	Includes components that are PSSCs that contain process fluids with trace quantities of plutonium or americium or non-radiological fluids. See Table 11.8.2 for applicable codes and standards. Positive material identification, inspection, and test requirements are used in engineering and procurement specifications for Category 2 components.
Category 3	Includes components that are non-PSSCs that may contain process fluids with trace quantities of plutonium or americium or non-radiological fluids that play a significant role for plant production reliability. See Table 11.8.3 for applicable codes and standards.
Category 4	Includes components as well as facility services that maintain production reliability. See Table 11.8.4 for applicable codes and standards.

Table 11.8.1, Design Basis Codes and Standards for Category 1 Fluid Transport System Components

FTS Category 1	Design Basis Codes and Standards
Process Vessels	ASME B&PV Code, Section VIII, Div. 1 or 2 for Lethal Service with enhanced positive material identification, & test and inspection requirements, 1995 Edition through the 1996 Addenda
Pumps	ASME B73.1 & B73.2 (specifications for horizontal end suction centrifugal and vertical in-line centrifugal pumps for chemical process, respectively) enhanced design specification of ASME materials with enhanced positive material identification, & test and inspection requirements Specialty pumps per manufacture's standards (e.g., submerged rotor seal-less pumps) American Petroleum Institute API Standard 610, Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
Piping	ASME B31.3, "Process Piping" Category M, with enhanced positive material identification, & test and inspection requirements
Valves	ASME B31.3, "Process Piping" Category M
Other Criteria	Seismic Category SC-1 and Quality Level -1 for all PSSCs

Table 11.8.2, Design Basis Codes and Standards for Category 2 Fluid Transport System Components

FTS Category 2	Design Basis Codes and Standards
Process Vessels	ASME B&PV Code, Section VIII, Div. 1 or 2 , 1995 Edition through the 1996 Addenda Compressed Gas Association S-1.1, "Pressure Relief Device Standards - Part 1 - Cylinders for Compressed Gases," and S-1.3, "Pressure Relief Device Standards - Part 3 - Stationary Storage Containers for Compressed Gases"
Pumps	ASME B73.1 & B73.2 Specialty pumps per manufacture's standards (e.g., submerged rotor seal-less pumps) American Petroleum Institute API Standard 610, "Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services" NFPA 20 - "Standard for the Installation of Stationary Pumps for Fire Protection"
Piping	ASME B31.3, "Process Piping" with enhanced test and inspection requirements
Valves	ASME B31.3, "Process Piping"
Other Criteria	Seismic Category SC-1 and Quality Level -1 for all PSSCs

Table 11.8.3, Design Basis Codes and Standards for Category 3 Fluid Transport System Components

FTS Category 3	Design Basis Codes and Standards
Process Vessels	ASME B&PV Code, Section VIII, Div. 1 or 2 , 1995 Edition through the 1996 Addenda Compressed Gas Association S-1.1, “Pressure Relief Device Standards - Part 1 - Cylinders for Compressed Gases,” and S-1.3, “Pressure Relief Device Standards - Part 3 - Stationary Storage Containers for Compressed Gases” UL-142, “Standard for Safety for Steel Aboveground Tanks for Flammable and Combustible Liquids”
Pumps	ASME B73.1 & B73.2 and Hydraulic Institute Standards Specialty pumps per manufacture’s standards (e.g., submerged rotor seal-less pumps) NFPA 20 - “Standard for the Installation of Stationary Pumps for Fire Protection”
Piping	ASME B31.3, “Process Piping”
Valves	ASME B31.3, “Process Piping”
Other Criteria	Conventional Seismic CS or SC-2, as applicable and Quality Level - 2, 3, or 4, as applicable

Table 11.8.4 Design Basis Codes and Standards for Category 4 Fluid Transport System Components

FTS Category 4	Design Basis Codes and Standards
Process Vessels	ASME B&PV Code, Section VIII, Div. 1 or 2, 1995 Edition through the 1996 Addenda Compressed Gas Association S-1.1, “Pressure Relief Device Standards - Part 1 - Cylinders for Compressed Gases,” and S-1.3, “Pressure Relief Device Standards - Part 3 - Stationary Storage Containers for Compressed Gases” UL-142, “Standard for Safety for Steel Aboveground Tanks for Flammable and Combustible Liquids”
Pumps	ASME B73.1 & B73.2 and Hydraulic Institute Standards Specialty pumps per manufacture’s standards (e.g., submerged rotor seal-less pumps)
Piping	ASME B31.3, “Process Piping”
Valves	ASME B31.3, “Process Piping”
Other Criteria	Conventional Seismic CS or SC-2, as applicable and Quality Level - 2, 3, or 4, as applicable

Table 11.8.5, Design Bases for the Fluid Transport Systems

FTS Component	Design Pressure	Design Temperature	Design Flow & Volumetric Capacity
Storage Tanks	The highest value of the following: • max. pressure - normal operations + 10% • max. pressure - normal operations + 0.9 bar [13 psig] • max. pressure - transient condition	The highest value of the following: • max. temp. - normal operations + 15°C [27°F] • max. temp. - transient condition	Maximum flow in normal operating conditions + 20%
Process Columns	Same as above	Same as above	Same as above
Heat Exchangers	Same as above	Same as above	Same as above
Pumps	Same as above	Same as above	Same as above
Prime Movers such as air lifts, ejectors, jets, siphons, etc.	Same as above	Same as above	• Process hydraulic calculation
Piping and Valves	Same as above	Same as above	• Pipe sizing per line velocity and pressure drop requirements

DCS' safety assessment, in Section 5.5 of the CAR, lists the following failure modes, related to fluid transport equipment, that could lead to a loss of confinement/dispersal of nuclear material events: corrosion occurring from within or from without on process equipment and leaks of AP process vessels or pipes within process cells. The material maintenance and surveillance programs and the qualifications of the fluid transfer systems to limit corrosion have been identified as PSSCs that reduce the risk to facility workers from corrosion. The safety function of the material maintenance and surveillance programs is to detect and limit the damage resulting from corrosion (principally associated with failures from corrosion occurring outside of process equipment). The safety function of the fluid transfer systems is to limit corrosion through the use of materials compatible with the environment and system fluids (principally associated with failures from corrosion occurring inside process equipment). No PSSCs are required to protect the public and site worker from this type of accident due to the low unmitigated consequences. However, the C4 and C3 confinement systems and the C2 passive boundaries provide defense-in-depth protection to the public and site worker. In regard to general corrosion allowances for equipment not accessible to inspection, and therefore not available for the material maintenance and surveillance program, design corrosion allowances could be credited for providing additional protection for the facility worker against corrosion. DCS has not provided information on the design basis for corrosion allowances for process equipment not readily available for inspection. This issue is considered an open item and is tracked in the "evaluation findings" section of this DSER. Corrosion allowances for specific AP process units (for corrosion mechanisms specific to a particular process or equipment configuration) will be discussed in Section 8.0, if applicable.

The process cell has been identified to reduce the risk to facility workers from leaks of AP process vessels or pipes within process cells. The safety function of the process cell is to contain leaks within process cells. The process cell entry controls have also been identified as PSSCs. The safety function of the process cell entry controls is to prevent the entry of personnel to process cells during normal operations and to maintain worker radiation doses within limits while performing maintenance in process cells. No PSSCs are required to protect the public and site worker from this type of accident due to the low unmitigated consequences.

However, the C3 confinement system provides defense-in-depth protection to the public and site worker.

Evaluation of Capacity: The staff evaluated the information provided by DCS in their CAR regarding the capacity of the proposed fluid transport systems. The staff notes that fluid transport systems with a safety function are identified as a PSSCs. The PSSCs in the fluid transport systems are designed to have adequate capacity to handle the volume of radioactive material during normal operation and design basis accident conditions. The components design basis is defined from thermal and hydraulic calculations and will consider the physical and chemical properties of the process fluid. The design flow and volumetric capacity design criteria were provided and discussed in Section 11.8.1.3. The nominal capacity of the process is 24 kg/day [52.9 lbs/day]. Solvents are recovered from the process as they are generated. Process heat is removed by intermediate cooling loops to the process chilled water system. Process heat is provided by the process steam system through the process hot water system. Both the process heat and cooling systems are sized to provide reliable and sufficient heating and cooling to the MFFF process systems. Drip trays in process cells are designed to contain radiological fluids and are sized to contain the contents from largest vessel in the cell and are shaped to maintain the leaked fluid in a criticality-safe geometry.

DCS has committed to design the fluid transport systems motivated by gravity, airflow, or steam-flow, to pass the process fluids at the required capacity and with a minimum of wear, material holdup, or corrosion.

Normal electrical power is removed from process prime movers during an earthquake event. Those electrical loads requiring power for safe-shutdown are supplied by emergency uninterrupted power. See Section 11.5 for additional discussion and the staff evaluation of the MFFF Electrical system.

Evaluation of Redundancy and Diversity: The SRP Section 11.4.7.2 states that the applicant should describe the redundancy and diversity of components required to prevent the release of radioactive materials to the environment or needed for safe operation of the fluid transport system. The fluid transport system is designed with multiple layers of confinement and is supplemented by administrative programs designed to monitor the integrity of these systems. Radiological fluids are maintained within at least two layers of confinement. Piping systems are double walled with leak detection systems if they are not located in process cells or gloveboxes. Drip trays with sump monitors are designed to detect leakage. The waste transfer line is double walled stainless steel piping with leak detection that is located in a trench routed away from heavy equipment areas and designed to withstand the normal loads like dead loads (soil pressure) and live loads (wheel loads) and a design basis earthquake event. The waste is pumped to SRS for storage and treatment using shielded lines. Level inside the tanks is remotely monitored using level instrumentation. The tank contents are sampled prior to start of transfer to SRS to ensure that they comply with the SRS Waste Acceptance Criteria. Various types of methods are used to transfer fluids, such as pumps, gravity, steam jet lifts, siphons, and airlifts. Hydraulic seals, as well as check valves, isolation valves of various types are used to isolate systems. Redundancy and diversity in the design is accomplished by the various factors of safety and types of equipment provided in the design and by the layering of active and passive controls that protect the fluid transport systems.

The fluid transport system is diverse in the control concepts for the process control systems that govern the fluid transport systems. The AP process control systems are designed to ensure that the product of the manufacturing process will conform to the product specifications with minimal waste and risk. They are composed of the normal, protective, and safety control subsystems. The normal control subsystem controls the MFFF normal manufacturing and processing operations. The protective control subsystem provides protection for personnel and equipment. The safety control subsystem is designed to ensure that safety limits will not be exceeded and that undesired operational conditions or events will not occur or will be mitigated. The staff has reviewed DCS's description of the fluid transport equipment and finds these systems to be diverse. On the basis of standard industry practices the staff finds the design to be acceptable.

Evaluation of Safe Shutdown: The staff evaluated the information provided by DCS in their CAR regarding the ability to safely shutdown the proposed fluid transport systems during normal and accident conditions and maintenance. The AP process control system, the electrical power system, and basic system design criteria primarily control the ability of the proposed systems to shutdown safely. The AP process instrumentation and control systems are designed to ensure that the product of the manufacturing process will conform to the product specifications with minimal waste and risk. They are composed of the normal, protective, and safety control subsystems. The normal control subsystem controls the MFFF normal manufacturing and processing operations. The protective control subsystem provides protection for personnel and equipment. The safety control subsystem is designed to ensure that safety limits will not be exceeded and that undesired operational conditions or events will not occur or will be mitigated. The PSSCs for the I&C systems are the safety subsystems of the MP and AP process control systems and utility control system and the hard-wired emergency control system. The I&C systems monitor and control plant parameters during normal and transient conditions to ensure that limits are not exceeded and to ensure the required quality of the product. They also provide signals to control equipment to prevent and mitigate faulted conditions. All emergency control equipment is qualified for design basis seismic events and normal, off-normal, and design basis accident environmental conditions. See Section 11.6 of this DSER for additional detail on instrumentation and control system safety.

Normal electrical power is removed from process prime movers during an earthquake event. Those electrical loads requiring power for safe-shutdown are supplied by emergency uninterrupted power. See the discussion on electrical systems safety in Section 11.5 of this DSER for more detail.

Basic system design criteria are applied to provide the first line of protection against events or hazards posed by process fluids. Radiological fluids are transferred using gravity flow, airlifts, air jets, steam jets, and siphons when practicable. Separator or "knockout pots" are needed in lines in which fluid transfer is made by air or vacuum lift. The separated fluid is allowed to flow by gravity into the desired component while the airflow vents at the top of the pot. This design prevents back flow siphoning. Steam jet lift transfer system piping is terminated in the receiving vessel vent space to provide an air gap that prevents back flow siphoning. Siphons are used to initiate gravity transfer of fluids in applications where flow rate is not critical. The siphon transfers liquid from the higher upstream tank to the lower downstream tank. The elevation difference between tanks prevents backflow.

Hydraulic seals are used to prevent backflow of process fluid to auxiliary systems during reagent addition. The liquid seal or "plug" is maintained by the piping configuration. The seal is implemented by a "U" bend in piping or by hydraulic seal pots. The hydraulic seal design ensures that the seal remains filled with liquid at all times, the seal withstands internal pressure differences between connected vessels, and that siphon action does not occur.

Check valves are used only in the process fluid pressure boundary. The check valve design basis is based on effective pressure drop, type of seating material, pressure and flow reversal response time, mounting requirements, and reliability and maintainability. Redundant isolation valves, that are PSSCs, are used to automatically isolate utility and reagent fluids in the process area when earthquake conditions are detected. The isolation valves, that are PSSCs, close in the event of valve or actuator failure. Isolation valve selection is based on process hydraulics, control system characteristics, mounting requirements, and other valve specifications. These valves may be of the following types: butterfly, gate, plug, or ball. The valves will be specified for service after consideration of the chemical characteristics of the fluid, piping material of construction, and operating conditions. The valves will be designed and constructed according to good engineering practices and in accordance with applicable codes, such as ASME B16.10, API-598, API-600/602/603/608/609. The valves and their supports will also be designed to withstand and remain operable during the design-basis earthquake.

Evaluation of Welded Construction: The regulatory acceptance criteria used for the review of this system specifically mentions tank and piping systems be of welded construction to the fullest extent possible. For process equipment, radiological fluids are maintained within at least two levels of confinement. Components containing fluids that are located in process cells are specified with corrosion allowances and welded joints are radiographed, as appropriate. Fluid transfer systems containing hazardous fluids are contained within trenches, rooms, or double-walled piping systems or are accessible for inspection and are of a fully welded construction. Components that are not of fully welded construction are installed in a glovebox. Piping components carrying radiological fluids between two confinements are either fully-welded double wall construction or are installed in gloveboxes. Welding requirements are contained in the ASME B&PV Code, Section VIII, 1995 Edition through the 1996 Addenda, ASME B31.3, and their referenced American Welding Society Codes. Welding work will be performed according to the FTS category and quality assurance plan quality level of the system being welded. Requirements for the qualification of welders and the welding process are specified in both the ASME B&PV Code, Section VIII, Division 1 and 2, 1995 Edition through the 1996 Addenda, and the ASME B31.3 codes. Other general design and technical specifications that will be used for welding are: ASME Sections II, V, and IX, ASTM codes, ANSI/AWS D-10.4 and B-3.0.

Material used for the construction of this equipment are specified in accordance with ASME and ASTM material specifications. ASME materials are used in the fabrication of equipment and piping components built to the requirements of ASME B&PV Code, Section VIII, Rules for Construction of Division 1 Pressure Vessels, 1995 Edition through the 1996 Addenda and ASME B31.3, Process Piping code. ASTM materials are also used for the fabrication of other components. In general design of equipment to these standards means that the components are designed for the most severe service conditions. Included in the severe service conditions are pressure, temperature, stress, material compatibility, and corrosion. The staff has reviewed DCS' design basis for welding and finds based on the information submitted referencing appropriate codes and standards for the design and construction of the fluid transport system that the design basis is acceptable.

Evaluation of Passive Features that Address Cross Contamination: The staff evaluated the information provided by DCS in their CAR regarding the passive features designed to prevent contamination of the fluid transport systems. The MFFF design basis for the fluid transport systems contains a significant number of passive features that help to prevent cross contamination.

Fluid transport components are hydraulically designed for the most severe service conditions. Radiological fluids are maintained within at least two levels of confinement. Fluid transfer systems containing hazardous fluids are contained within trenches, rooms, or double walled piping systems or are accessible for inspection and are of a fully-welded construction. All piping components designated as PSSCs are designed to withstand the design basis earthquake loads.

Separator or “knockout pots” are specified for piping in which fluid transfer is made by air or vacuum lift. The separated fluid is allowed to flow by gravity into the desired component while the airflow vents at the top of the pot. This design prevents back flow siphoning. Steam jet lift transfer system piping is terminated in the receiving vessel vent space to provide an air gap that prevents back flow siphoning. Siphons are used to initiate gravity transfer of fluids in applications where flow rate is not critical. The siphon transfers liquid from the higher upstream tank to the lower downstream tank. The elevation difference between tanks prevents backflow. Knockout pots, steam jet lifts, and elevation differences between tanks are passive features that help to prevent cross contamination.

Hydraulic seals are used to prevent backflow of process fluid to auxiliary systems during reagent addition. The seal is implemented by a “U” bend in piping or by hydraulic seal pots. The hydraulic seal design ensures that the seal remains filled with liquid at all times, the seal withstands internal pressure differences between connected vessels, and that siphon action does not occur. Hydraulic seals are passive features that help to prevent cross contamination.

Check valves are used only in the process fluid pressure boundary. Redundant isolation valves, that are PSSCs, are used to automatically isolate utility and reagent fluids in the process area when earthquake conditions are detected. The isolation valves close in the event of valve or actuator failure. Check valves in the process fluid pressure boundary and isolation valves that fail to the safe position are examples of passive safety features that help to prevent cross contamination. DCS has committed to the design basis previously discussed. The staff has reviewed the facility design basis for cross contamination, and based on nuclear industry experience, concludes that the design is acceptable.

Evaluation of Radiation Safety: The staff review and evaluation of the radiation safety program is discussed in detail in Section 6.0 of this SER. In general, the design basis for the fluid transport systems hardware for radiation safety is as follows: process equipment is designed to handle fissile material in accordance with radiation safety principles; stainless steel and other material designed to be compatible with process fluids will be used to prevent corrosion; parts are easy visible and accessible for cleaning, material are specified with appropriate surface quality or coatings, if needed; process cell drip trays will be designed to contain the contents of the largest vessel in the process cell in a critically safe configuration; decontamination will be done by flushing and high pressure washing to remove sediment buildup or blockages, should they occur; and the fluid transport systems layout is intended to minimize the potential for entrapment and buildup of radioactive materials. Based on DCS’ commitment to design the system to minimize the entrapment and buildup of radioactive materials, the staff finds this design to be acceptable.

Evaluation of Corrosion Resistance: The MOX FFF fluid transport systems construction materials are selected based on compatibility with the physical and chemical characteristics of the process fluids. In general, stainless steel of type 304L or 316L and alloys of titanium and zirconium are used for fluid transport system (FTS) Category 1 components. Components of FTS Category 2 and 3, that are handling acidic or alkaline fluids are generally constructed from 304L or 316L stainless steel. Material used for the construction of this equipment are specified in accordance with ASME and ASTM material specifications. ASME materials are used in the fabrication of equipment and piping components built to the requirements of ASME B&PV Code, Section VIII, Rules for Construction of Division 1 Pressure Vessels, 1995 Edition through the 1996 Addenda, and ASME B31.3, Process Piping code. ASTM materials are also used for the fabrication of other components. In general, design of equipment to these standards means that the components are designed for the most severe service conditions. Included in the severe service conditions are pressure, temperature, stress, and corrosion. Specifically, in order to make a conclusion as to the adequacy of their corrosion design basis, the staff requires additional information on DCS's design basis for corrosion allowances for process equipment that will not be readily inspectable; such as fully welded process equipment located in process cells. Therefore, the design basis for corrosion allowances of equipment inside process cells has not been adequately resolved and is considered an open issue.

Evaluation of Personnel Protection: The NRC SRP requires the evaluation of the need for hoods, gloveboxes, and shielding for personnel protection. These systems are generally required for wet processing operations involving more than gram quantities of plutonium or general operations involving 50 micrograms or more or plutonium in respirable form. In its clarification letter to its original response to NRC's RAI, dated December 5, 2001, DCS stated that the equipment that meets the stated conditions are all located in process cells. Process cells contain equipment that handles radioactive materials in chemical solutions; the equipment being of a fully welded construction and not requiring routine maintenance. Equipment containing radioactive materials in the powder (MP) process is contained in gloveboxes in process rooms that provide equivalent confinement to fully welded equipment in process cells. The staff has reviewed DCS' list of equipment and agrees that the equipment involving more than gram quantities of plutonium or general operations involving 50 micrograms or more or plutonium in respirable form are properly contained in either gloveboxes or fully welded process equipment. Therefore, based on the facility design following the guidelines of the NRC SRP, the staff finds this design basis to be acceptable.

Evaluation of Functionality During Severe Natural Phenomena: Fluid transport systems designated as PSSCs are designed and qualified according to national codes and standards enabling them to perform their safety function during normal operations, upset conditions, and design basis events. These codes and standards are delineated in Tables 11.8.0, 11.8.1, and 11.8.2 of this SER. These codes and standards protect the ability of the primary process to perform safety functions and maintained, as appropriate. The seismic monitoring system is designed to satisfy the criteria provided in Regulatory Guide 3.17-1974, "Earthquake Instrumentation for Fuel Reprocessing Plants." The design basis of the seismic monitoring system is that it provides sufficient data to evaluate the response of the confinement structure and other PSSCs to a seismic event and initiate a shutdown of process systems in the event of a high seismic event. The seismic system will meet the requirements of IEEE Standard 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," 1998. Seismic qualification requirements are applied using a graded classification program that considers the relative importance of the safety function and the structural behavior of the PSSC. See the discussion of quality assurance classes and grading in Section 15.1 of this

SER for details on implementation. This classification system is defined in Regulatory Guide 3.14, “Seismic Design Classification for Plutonium Processing and Fuel Fabrication Plants,” 1973. Seismic Category 1 (SC-I) classification is applicable to MFFF SSCs and the supporting SSCs that are required to withstand the effects of an earthquake and remain functional to the extent that they will prevent the uncontrolled release of radioactive materials. The SC-I classification applies to all PSSCs that must perform a safety function during and/or after the design basis earthquake to comply with the MFFF safety assessment as discussed in Section 5.0 of this SER. Seismic Category II (SC-II) applies to the portions of systems whose continued function is not required but whose failure could reduce the functioning of any plant feature of a SC-I SSC. Items that are neither SC-I or SC-II are not classified with respect to seismic category. Components that form an interface between SC-I and non-SC-I components should be classified as SC-I. The QA plan will apply to these components as previously discussed.

11.8.2 EVALUATION FINDINGS

In Section 11.8 of the CAR, DCS provided design basis information for the fluid transport systems that it identified as PSSCs for the proposed MFFF. Based on the staff's review of the CAR and supporting information provided by the applicant relevant to the fluid transport systems, the staff cannot conclude, pursuant to 10 CFR 70.23(b), that the design bases of the PSSCs identified by the applicant will provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. The open issue is as follows:

- The staff requires DCS to provide information on the methodology for specifying corrosion allowances for principal SSCs located in process cells not accessible for inspection. (Section 11.8.1.3)

11.8.3 REFERENCES

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11.8.3.2 American National Standards Institute/American Petroleum Institute (ANSI/API). Standard 610, “Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services.” ANSI/API: August 1995.

11.8.3.3 _____. ANSI/API Standard 600, “Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries - Modified National Adoption of ISO 10434:1998.” ANSI/API: October 2001.

11.8.3.4 _____. ANSI/API Standard 608, “Metal Ball Valves-Flanged, Threaded and Butt-welding Ends.” ANSI/API: September 1995.

11.8.3.5 American Petroleum Institute (API). Standard 598, “Valve Inspection and Testing.” API: October 1996.

11.8.3.6 _____. Standard 602, “Compact Steel Gate Valves - Flanged, Threaded, Welding, and Extended Body Ends.” API: October 1998.

11.8.3.7 _____. Standard 603, "Corrosion-Resistant, Bolted Bonnet Gate Valves-Flanged and Butt-welding Ends." API: April 2001.

11.8.3.8 _____. API Standard 609, "Butterfly Valves: Double Flanged, Lug- and Wafer-type." API: May 1997.

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11.8.3.10 American Society of Mechanical Engineers (ASME). ASME B16.10, "Face-to-Face and End-to-End Dimensions of Valves." ASME: 2000.

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11.8.3.15 _____. Standard S-1.3, "Pressure Relief Device Standards - Part 3 - Stationary Storage Containers for Compressed Gases." CGA: 2001.

11.8.3.16 Giitter, J., U.S. Nuclear Regulatory Commission, letter to Hastings, P., Duke Cogema Stone & Webster, RE MFFF Construction Authorization - Request for Additional Information, June 21, 2001.

11.8.3.17 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Response to Request for Additional Information, August 31, 2001.

11.8.3.18 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information (DCS-NRC-000074), December 5, 2001.

11.8.3.19 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, (DCS-NRC-000081) January 7, 2002.

11.8.3.20 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, (DCS-NRC-000085) March 8, 2002.

11.8.3.21 Ihde, R, Duke Cogema Stone & Webster, letter to W. Kane, U.S. Nuclear Regulatory Commission, RE. Mixed Oxide Fuel Fabrication Facility—Construction Authorization Request, February 28, 2001.

11.8.3.22 Institute of Electrical and Electronics Engineers (IEEE). Standard 344, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations." IEEE: 1987.

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11.8.3.30 Persinko, A., U.S. Nuclear Regulatory Commission (NRC), memorandum to E.J. Leeds, NRC, RE: 2/13/02 Meeting Summary: MFFF Program Changes and Applicant Reorganization, February 27, 2002.

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