Mixed Oxide Fuel Fabrication Facility

License Application
27 September 2006

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List of Acronyms and Abbreviations

μCi	microCuries
ac	acre
AC	alternating current
AEGL	Acute Exposure Guideline Level
AFS	Alternate Feedstock
ALARA	as low as is reasonably achievable
ALI	annual limit of intake
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOA	area of applicability
AP	Aqueous Polishing
ARM	area radiation monitor
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BAD	Administration Building
BAP	Aqueous Polishing Area
BAQ	Bureau of Air Quality
BEG	Emergency Generator Building
BLWM	Bureau of Land and Waste Management
BMF	MOX Fuel Fabrication Building
BMP	MOX Fuel Fabrication Area (MOX Processing Area)
Bq	Becquerel
BRP	Reagent Processing Building
BRW	Receiving Warehouse Building
BSG	Standby Generator Building
BSR	Shipping and Receiving Area
BSW	Secured Warehouse Building
BTS	Technical Support Building
BWQ	Bureau of Water Quality
CAM	continuous air monitor
CAR	Construction Authorization Request
CASRN	Central Abstract System Registry Number
CDE	committed dose equivalent
CECP	Construction Emissions Control Plan
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
cm	centimeter
CM	configuration management
COE	U.S. Army Corps of Engineers
CSAS	criticality safety analysis sequence
DAC	Derived Air Concentration
DC	direct current
DCS	Duke, Cogema, Stone & Webster
DDE	deep dose equivalent

DE	dose equivalent
DEAR	Department of Energy Acquisition Regulations
DER	dose equivalent rate
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DUO_2	depleted uranium oxide
EALF	energy of average lethargy causing fission
EDMS	electronic data management system
EMMH	external man-made hazard
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
eV	electron volt
FD	Fire Department
FHA	Fire Hazards Analysis
FMEA	failure modes and effects analysis
FOCI	foreign ownership, control, or influence
fpm	feet per minute
ft	foot/feet
FTS	Fluid Transport system
HAN	hydroxylamine nitrate
HAZOP	hazard and operability study
HDE	High Depressurization Exhaust
HED	human engineering discrepancy
HEPA	high efficiency particulate air
HFE	human factors engineering
HPCA	Health Physics Control Area
HS&E	health, safety, and environment
HSI	human-system interface
HVAC	heating, ventilation, and air conditioning
I&C	Instrumentation and Control
IEEE	Institute of Electrical and Electronic Engineers
IOC	individual outside of the controlled area
IROFS	items relied on for safety
ISA	integrated safety analysis
keV	kilo electron volt
kg	kilogram
km	kilometer
kV	kilovolt
kW	kilowatt
KWG	Offgas Treatment Unit
LA	License Application
lb	pound
LDE	lens of the eye dose equivalent
LLC	Limited Liability Company
LLD	lower limit of detection
LWR	Light Water Reactor

m	meter
MCNP	Monte Carlo N-Particle
MDE	Medium Depressurization Exhaust
MeV	megavolt
MFFF	Mixed Oxide Fuel Fabrication Facility
mg	milligram
mi	mile
ml	milliliter
MOX	mixed oxide
MP	MOX Processing
MPQAP	MOX Project Quality Assurance Plan
mrem	millirem
NCS	nuclear criticality safety
NCSE	nuclear criticality safety evaluation
NDA	nondestructive assay
NDE	nondestructive examination
NESHAP	National Emission Standard for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIM	nuclear incident monitoring
NIST	National Institute of Standards and Technology
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPH	natural phenomena hazard
NRC	U.S. Nuclear Regulatory Commission
NSE	Nuclear Safety Evaluation
pCi/g	picoCuries/gram
PDCF	Pit Disassembly and Conversion Facility
PEP	personnel and equipment protection
PHA	Preliminary Hazard Analysis
POE	Process Cell Depressurization Exhaust
PrHA	Process Hazards Analysis
Pu	plutonium
PUCR	Polishing and Utilities Control Room
PuO_2	plutonium oxide
QA	Quality Assurance
QL	Quality Level
RAB	restricted area boundary
RCRA	Resource Conservation and Recovery Act
RCZ	radiological control zone
rem	Roentgen Equivalent in Man/Mammal
RM/HPR	Respiratory Protection and Health Physics Room
RNA	Nitric Acid system
RPM	Radiological Protection Functional Manager
RWP	Radiation Work Permit
S&W	Stone & Webster, Inc.
SA	safety assessment

SAS	Service Air system
SCAPA	DOE Subcommittee on Consequence Assessment and Protective Actions
SCDHEC	South Carolina Department of Health and Environmental Control
SDE	shallow dose equivalent
SGF	Standby Diesel Generator Fuel Oil System
SHPO	State Historic Preservation Officer
SNM	special nuclear material
SPCC	Spill Prevention Control and Countermeasures
SPS	Steam and Condensate system
SPSG	Shaw Project Services Group, Inc.
SRS	Savannah River Site
SSCs	structures, systems, or components
Sv	Sievert
SWPPP	Stormwater Pollution Prevention Plan
TBP	tributyl phosphate
TEDE	total effective dose equivalent
TLD	Thermoluminescent Dosimeter
UEF	Emergency Fuel Storage Vault
UEF	Emergency Fuel Storage Vault
UGS	Gas Storage Area
UO_2	uranium oxide
USF	Standby Diesel Fuel Storage
USFWS	U.S. Fish and Wildlife Services
USL	upper safety limit
USNRCS	U.S. Natural Resources Conservation Service
UST	underground storage tank
V	volt
V&V	verification and validation
VAC	volts alternating current
VDC	volts direct current
VHD	Very High Depressurization Exhaust System
WAC	Waste Acceptance Criteria
WVA	Vehicle Access Portal
yr	year

1. GENERAL INFORMATION

1.1 FACILITY AND PROCESS OVERVIEW

1.1.1 Introduction

The consortium of Shaw Project Services Group, Inc., AREVA NC, Inc., and Stone & Webster, Inc., has formed a Limited Liability Company (LLC) called Duke Cogema Stone & Webster (DCS). DCS seeks authorization to possess and use by-product material, source material, and special nuclear material at the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF), which is owned by the U.S. Department of Energy (DOE), located on DOE's Savannah River Site (SRS) near Aiken, South Carolina. The MFFF is designed to convert surplus weapons-grade plutonium to MOX fuel that can be used to generate electricity at commercial nuclear power stations. The fabrication of the MOX fuel, which is a blend of uranium and plutonium oxides, is based on the proven European technology of AREVA NC.

This license application is written in the present tense. It describes the MFFF site, design features, processes, programs, commitments, etc., in effect in the time perspective of receipt of the U.S. Nuclear Regulatory Commission (NRC) approved license for possession and use of nuclear materials for operation of the facility.

1.1.2 General Facility Description

The MFFF is located in F Area of SRS as indicated in Figure 1.1-1. The arrangement of the buildings and facilities of the MFFF is shown in Figure 1.1-2.

The MFFF site comprises an area of approximately 41 acres. Approximately 17 acres of the site are developed with buildings, facilities, or paving. The remaining 24 acres are landscaped in either grass or gravel. No highways, railroads, or waterways traverse the MFFF site, and the movement of material and personnel to and from the MFFF site takes place via the SRS internal road system. Transportation right-of-ways are shown on Figure 1.1-1. The public transportation right-of-way nearest to the MFFF site and F Area is South Carolina Route 125 to the west. Access to the MFFF site is via SRS Roads C and C-3.

1.1.3 Controlled Area Boundary

In accordance with Title 10 of the Code of Federal Regulations (CFR) §20.1003, a *restricted area* is "an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials." The MFFF Restricted Area is coincident with the Protected Area, an area encompassed by physical barriers and to which access is controlled as shown on Figure 1.1-2.

In accordance with 10 CFR §70.61(f), a licensee must establish a controlled area and retain the authority to exclude or remove personnel and property from the area. A *controlled area* as defined in 10 CFR §20.1003 is "an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason."

The Controlled Area established for the MFFF includes those areas and buildings that are under DCS control and that are a direct part of the MFFF. The Controlled Area Boundary (the perimeter of the Controlled Area) is coincident with the MFFF site boundary and is depicted in Figure 1.1-2.

1.1.4 Buildings

1.1.4.1 MOX Fuel Fabrication Building

The MOX Fuel Fabrication Building is a multifunctional complex containing the plutonium oxide (PuO_2) handling, fuel processing, and fuel fabrication and repair operations of the MFFF. The vent stack, where ventilation exhaust is discharged, is located on top of this building.

The MOX Fuel Fabrication Building is comprised of three major functional, interrelated areas: the MOX Processing (MP) Area, the Aqueous Polishing (AP) Area, and the Shipping and Receiving Area. The MP Area includes areas for the decanning, milling, and recanning of PuO_2; for the blending, pelletizing, milling, sintering, and grinding of MOX fuel; for fuel rod fabrication and fuel bundle assembly; a laboratory area; and storage areas for feed material, pellets, and fuel assemblies. The AP Area includes areas for dissolution, dechlorination, purification, solvent recovery, conversion (calcination), for powder homogenization, canning and sampling, and for auxiliary processes such as oxalic mother liquor recovery, acid recovery, offgas treatment, waste organic solvent and aqueous waste reception and storage. The Shipping and Receiving Area includes areas for loading or unloading trucks. Space is also provided for support equipment, such as temporary solid waste storage; heating, ventilation, and air conditioning (HVAC) equipment; high-efficiency particulate air (HEPA) filter plenums; power inverters; and electrical switchgear.

1.1.4.2 Emergency Generator Building

The Emergency Generator Building contains the emergency diesel generators that provide the emergency onsite electrical power supply during a total loss of power for loads that are items relied on for safety (IROFS) in the MFFF. Each of the two seismically-mounted emergency diesel generators and associated equipment is enclosed within a separate diesel generator room. Supporting electrical equipment is located adjacent to the diesel generator rooms. The emergency fuel storage vault, located adjacent to the Emergency Generator Building, provides support and protection for the diesel fuel storage tanks for the emergency diesel generators.

1.1.4.3 Standby Generator Building

The Standby Generator Building contains the diesel generators that provide the onsite electrical power source for major loads in the event of loss of offsite power. The building contains two standby diesel generators and associated equipment. Supporting electrical equipment is located adjacent to the diesel generator rooms. Diesel fuel for the standby generators is stored in an underground storage facility.

1.1.4.4 Secured Warehouse Building

The Secured Warehouse Building contains areas for storing depleted uranium and small parts, as well as office and maintenance areas.

1.1.4.5 Administration Building

The Administration Building, located outside of the Protected Area of the MFFF complex, provides administrative support to the MFFF and its operations. Space is provided in the building for facility management, facility production, nuclear material accounting, administration, health and safety, quality assurance, NRC personnel, document control, and a computer simulation lab.

1.1.4.6 Technical Support Building

The Technical Support Building provides the main support facilities for MOX Fuel Fabrication Building personnel and contains the access facilities for the Protected Area and the MOX Fuel Fabrication Building. The Technical Support Building is located between the Administration Building and the MOX Fuel Fabrication Building and is not directly involved in the principal processing functions of the MFFF. Supporting activities and facilities located in this building include radiation protection, electronics maintenance, mechanical maintenance, personnel lockers, a first aid station, and respirator and dosimetry issue.

The Access Control Area, located on the first level of the Technical Support Building, serves as the sole personnel access (except for vehicle drivers escorted in and out of the vehicle access portal) into and out of the Protected Area, through the personnel access portal.

1.1.4.7 Reagent Processing Building

The Reagent Processing Building, located adjacent to the AP Area of the MOX Fuel Fabrication Building, houses equipment for the preparation and storage of reagent grade chemicals used in the AP process. The Reagent Processing Building consists of a number of separate rooms/areas for the preparation and distribution of various chemicals. Concrete curbs around the chemical storage areas provide for spill containment. One end of the building has a loading dock for transfer of chemical drums in and out of the building. Chemicals are transferred to the AP Area from the Reagent Processing Building via piping located in a concrete, below-grade enclosed trench between the two buildings.

1.1.4.8 Receiving Warehouse Building

The Receiving Warehouse Building contains areas for receipt, unpacking, inspection, and temporary storage of material, supplies, and equipment prior to transfer through the perimeter intrusion detection and assessment system into the Protected Area or to the Administration Building. Licensed materials are not received at this facility.

1.1.4.9 Miscellaneous Site Structures

The miscellaneous site structures include a bulk gas storage pad, HVAC and process chiller pads, diesel fuel filling station, electrical transformers, and other minor structures.

1.1.5 Material Flow

1.1.5.1 Plutonium Oxide Feed Material

PuO_2 feed material, transported in approved shipping containers, is received in the Shipping and Receiving Area of the MOX Fuel Fabrication Building. The feed material is offloaded in the PuO_2 truck bay where the outer packaging is removed. The feed material is then moved to the MP Area for sampling and storage for process use. Material control and accounting and radiation protection functions are performed.

1.1.5.2 Depleted Uranium Oxide Feed Material

Depleted uranium oxide (DUO_2) feed material, which is packaged in drums and shipped by truck, is received and stored in the DUO_2 storage area of the Secured Warehouse Building. Onsite vehicles transfer DUO_2 to the truck bay in the Shipping and Receiving Area, as needed in the MP Area.

1.1.5.3 Completed Fuel Assembly Handling

Completed fuel assemblies are stored in the assembly storage vault in the MP Area. For shipment offsite, the assemblies are loaded into a MOX fresh fuel shipping cask and conveyed into the Shipping and Receiving Area for loading onto a transport vehicle.

1.1.5.4 Conventional Materials

Other conventional materials and supplies are received at the Receiving Warehouse Building. Packing materials are removed, and the materials, supplies, or equipment are verified and inspected. The materials, supplies, or equipment are sorted and moved to storage in the Secured Warehouse Building, or delivered via onsite vehicles to other areas where needed.

1.1.5.5 Personnel Movement

The Administration Building contains offices for management, administration, production, health and safety, and quality assurance personnel. Personnel enter the Protected Area through the personnel access portal in the Technical Support Building. Workspaces for security and production support personnel are located in this building.

1.1.6 Radioactive Effluents and Waste Disposition

Radioactive effluents and waste disposition are described in Chapter 10.

1.1.7 Process Overview

The MFFF is designed to purify PuO_2 and then blend it with DUO_2 to produce completed MOX fuel assemblies for use in nuclear power reactors. The MFFF has two major process operations: (1) an aqueous polishing process, which serves primarily to remove americium, gallium, and other impurities from the plutonium, and (2) the MOX fuel fabrication process, which processes the oxides into pellets and manufactures the MOX fuel assemblies. These processes are designed and integrated so that waste and discarded powder/pellet material streams are recycled to the extent practical. The major steps in the aqueous polishing and MOX fuel fabrication processes are shown in Figure 1.1-3.

1.1.7.1 Aqueous Polishing Process

The DOE Pit Disassembly and Conversion Facility (PDCF), located nearby the MFFF, disassembles plutonium pits from weapons and converts the plutonium to PuO_2 for use as MFFF feedstock. A smaller amount of PuO_2 from other DOE sources is also utilized as MFFF feedstock (alternate feedstock).

The PuO_2 received at the MFFF contains small amounts of impurities that must be removed before the MOX fuel is used in reactors. The aqueous polishing process is used to remove these impurities through a wet extraction process. Impurities in the PDCF feeds are primarily gallium, americium, and highly enriched uranium. Alternate feedstocks may contain those and other impurities at higher contaminant levels and may also contain chlorides and other salt contaminants. The aqueous polishing process involves the following three major steps: dissolution, purification, and conversion.

The dissolution step consists of the electrolytic dissolution of PuO_2 powder in nitric acid, and subsequent filtration of the plutonium nitrate solution. Hydrogen peroxide is added to the aqueous nitrate stream to reduce plutonium from the +6 to the +4 valence state so that it can be extracted during the purification step. For PuO_2 containing significant quantities of chlorides, a dechlorination step is utilized prior to dissolution. Chloride ions are electrolytically oxidized and removed from the process stream as chlorine gas. The gas stream is scrubbed of chlorine and then treated in the offgas system.

The purification step includes plutonium extraction with an organic solvent. This step also includes auxiliary processes for recovery of solvent and acid. Plutonium is extracted from the nitrate solution in pulsed columns by contact with a 30% tri-butyl phosphate (TBP)/ hydrogenated tetrapropylene solution. The plutonium and uranium are extracted into the organic phase and the impurities (americium, gallium, silver, etc.) remain in the aqueous phase as raffinates. The plutonium is then separated from the uranium in the solvent by reducing the plutonium from the +4 to the +3 valence state with the addition of hydroxylamine nitrate and acid stripping, during which the plutonium is removed from the organic stream into the aqueous stream. In the aqueous purified nitrate stream, the plutonium valence is oxidized back to the +4 state by passing nitrous fumes (NO_X) through the plutonium solution in a packed column. Downstream of the plutonium separation process, the solvent solution with the plutonium removed is stripped of uranium with a nitric acid solution. The unloaded solvent solution is sent to the solvent recovery unit, while the uranium stream is sent to the aqueous liquid waste system.

The organic waste streams are collected and sent to the solvent recovery unit where they are scrubbed in a multistage mixer-settler unit to remove the degradation products. The composition of the solvent mixture is adjusted to 30% TBP in the multistage mixer-settler before being recycled to the purification step.

Various aqueous waste streams are collected and sent to the acid recovery unit where the raffinates are concentrated and the nitric acid is recovered in a two-step concentration process that is followed by rectification. The recovered acid is then reused in the process while excess acid and concentrated raffinates are sent to the aqueous waste stream.

The conversion step converts the purified plutonium nitrate stream to PuO_2 powder by the processes of precipitation and calcination. The plutonium nitrate stream is reacted with oxalic acid to form a plutonium oxalate slurry that is collected by a filter and dried in a rotary calciner where the oxalate is converted into oxide at high temperature. The PuO_2 powder is then homogenized, sampled, and stored in cans for use in the fuel fabrication process. The filtered oxalic liquor stream is treated with manganese to facilitate the decomposition of the oxalates, concentrated, and then recycled to the beginning of the extraction cycle to maximize plutonium recovery. Offgas from the rotary calciner is routed through HEPA filters prior to discharge to the atmosphere through the plant vent stack.

1.1.7.2 MOX Fuel Fabrication Process

The MOX fuel fabrication process consists of four major steps: (1) powder master blend and final blend production, (2) pellet production, (3) rod production, and (4) fuel rod assembly.

The first operation is the production of the powder master blend. Polished PuO_2 is mixed with DUO_2 and recycled powder/pellet material to produce an initial mixture that is approximately 20% plutonium. This mixture is subjected to micronization in a ball mill and mixed with additional DUO_2 and recycled material to produce a final blend with the required plutonium content (typically from 2% to 6%). This final blend is further homogenized to meet plutonium distribution requirements. During the final homogenizing steps, a lubricant and poreformer are added to control density.

The final homogenized powder blend is pressed to form “green” pellets, which are then sintered to obtain the required ceramic qualities. The sintering step removes organic products dispersed in the pellets and removes the previously introduced poreformer. The sintered pellets are ground to a specified diameter in centerless grinding machines and sorted. Powder recovered from grinding and discarded pellets are recycled through a ball mill and reused in the powder processing.

Fuel rods are loaded to an adjusted pellet column length, pressurized with helium, welded, and then decontaminated. The decontaminated rods are removed from the gloveboxes and placed on racks for inspection and assembly. Fuel rods are inserted into the fuel assembly skeleton, and the fuel assembly construction is completed. Each fuel assembly is subjected to a final inspection prior to shipment in a DOE fresh fuel shipping cask.

1.2 INSTITUTIONAL INFORMATION

1.2.1 Corporate Identity

DCS is the applicant for the license to possess and use by-product material, source material, and special nuclear material (SNM). DCS is incorporated in the State of South Carolina as an LLC owned by Shaw Project Services Group, Inc. (SPSG, owned by Shaw Environmental & Infrastructure, Inc.), AREVA NC, Inc., and Stone & Webster, Inc. (S&W). These three companies are the equity owners of the LLC (SPSG 40%, AREVA NC 30%, and S&W 30%). DCS was formed to provide MOX fuel fabrication and other services to support the mission of DOE for the disposition of U.S.-owned surplus weapons-usable plutonium. The applicant's mailing address is:

Duke Cogema Stone & Webster
Savannah River Site
P. O. Box 7097
Aiken, SC 29804-7097

The applicant's shipping address is:

Duke Cogema Stone & Webster
Savannah River Site, Building 730-2B
Aiken, SC 29808

DOE is the owner of the MFFF, which is located at SRS in Aiken, South Carolina. DCS is a South Carolina LLC whose direct owners are all U.S. corporations. AREVA NC, Inc. (formerly COGEMA, Inc.), which owns a minority share of DCS (30%), is itself a wholly owned subsidiary of AREVA NC, a French company. SPSG and S&W together hold a 70% majority interest in DCS. As a result, there is no direct foreign ownership, no foreign control, and no significant foreign interest in DCS. Furthermore, in awarding the contract to DCS to design, construct, and operate the MFFF, DOE engaged in a foreign ownership, control, or influence (FOCI) review in accordance with DOE Order 470.1, "Safeguards and Security Program." Based upon that review, DOE rendered a favorable FOCI determination on 9 July 1999, based on a Security Control Agreement between Duke Cogema Stone & Webster, LLC and DOE, mitigating Foreign Ownership, Control, or Influence. Additionally, favorable FOCI determinations have been made for Shaw Project Services Group (10 June 2002) and Stone & Webster, Inc. (through reciprocity with the Department of Defense).

The principal DCS corporate officers (and citizenship) are:

K. David Stinson, President and Chief Operating Officer (USA)
Dirk Leach, Vice President, Deputy Project Director (USA)
Van Coats, Vice President (USA)
Jean-Noël Alibert, Vice President, Fuel Services (France)
Walter L. Elliott, Vice President, Engineering Services (USA)
Corwin R. Bishop, Vice President, Construction Services (USA)
S. Casey Kenney, Vice President and Chief Administrative Officer (USA)

Sue M. King, Vice President, Projects (USA)
Gwen Nalls, Secretary and Treasurer (USA)

The common address for all the officers listed above is:

Duke Cogema Stone & Webster
Savannah River Site
P. O. Box 7097
Aiken, SC 29804-7097

DCS is solely responsible for the design, construction management, and operation of the MFFF. In addition to the SPSG and S&W engineering expertise, and AREVA NC operations expertise, the following companies provide technical support:

- SGN, a wholly owned subsidiary of AREVA NC, for facility and process design experience
- MELOX, a wholly owned subsidiary of AREVA NC, for operations experience
- AREVA NP (formerly Framatome ANP) for operations and engineering experience
- Nuclear Fuel Services, Inc. for Safeguards and Security experience.

1.2.2 Type and Period of License and Type, Quantity, and Form of Licensed Material

DCS requests a license to receive, acquire, possess, use, store, and transfer by-product material, source material, and SNM. The requested period of the license is 20 years.

Authorization is requested for the types, maximum quantities, and forms of by-product material, source material, and SNM provided in Table 1.2-1.

1.2.3 Proposed Authorized Uses

Authorized activities at the MFFF include receipt, handling, storage, and shipment of plutonium- and uranium-bearing materials for the following uses:

Aqueous Polishing

- Mechanical powder pretreatment (feed material dependent)
- Dissolution and chloride removal (feed material dependent)
- PuO_2 dissolution by electrolytic dissolution
- Plutonium purification by solvent extraction
- Conversion into PuO_2 by precipitation and calcination.

MOX Processing

- Blending and milling of plutonium, uranium, and mixed oxides
- Pelletizing
- Fuel rod and assembly manufacturing, inspection, and repair/rework

- Laboratory operations
- Discarded powder/pellet material and waste processing.

1.2.4 Special Exemptions/Authorizations

1.2.4.1 Decommissioning

DOE will assume responsibility for decommissioning the MFFF as discussed in SECY 99-177, "Current Status of Legislative Issues Related to NRC Licensing a Mixed Oxide Fuel Fabrication Facility," Issue 8. DCS has submitted under separate cover a request for an exemption from decommissioning requirements.

As described above, DOE will assume responsibility for decommissioning. Therefore, the method of financial assurance is in accordance with 10 CFR §70.25(f)(5) and 10 CFR §40.36(e)(5).

1.2.4.2 Financial Protection

SECY 99-177, Issue 7, addresses the issue of Price-Anderson liability coverage. DOE has agreed to indemnify DCS in accordance with Section 170(d) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. 2210(d), and Department of Energy Acquisition Regulation (DEAR) 952.250-70 (48 CFR §952.250-70). Because the DOE indemnity will apply to the MFFF, there is no need for the application of the NRC financial protection requirements. DCS has submitted under separate cover a request for an exemption pursuant to 10 CFR §140.8 from the requirements of 10 CFR Part 140, including the requirement of 10 CFR §140.13a to provide $200 million in financial protection.

1.2.4.3 Labeling

DCS has submitted under separate cover a request for an exemption from the labeling requirements of 10 CFR §20.1904(a) because of the nature of the MFFF operation. The intent of these sections is met by posting areas that house or temporarily store radioactive material with signs incorporating the radiation symbol and with the warning: "CAUTION RADIOACTIVE MATERIAL; ANY CONTAINER IN THIS AREA MAY CONTAIN RADIOACTIVE MATERIAL". This exemption is based on practicality and industry experience applied effectively at other licensed SNM handling facilities.

1.2.4.4 Prior Commitments

All commitments made to the NRC prior to the most recent NRC approved revision of this license application shall no longer be binding upon DCS, unless imposed as license conditions.

1.2.4.5 Frequencies

When measurement, surveillance, and/or other frequencies are specified in this License Application or other license commitments, the following shall apply:

- DAILY means once each 30-hour, or less, period.

- WEEKLY means once each eight, or less, consecutive days.
- MONTHLY means 12 per year, with each covering a span of 40-days or less.
- SEMIMONTHLY means twice a month, each covering a span of 20-days or less.
- BIMONTHLY means every 2 months, with each covering a span of 70-days or less.
- QUARTERLY means four per year, with each covering a span of 115-days or less.
- SEMIANNUAL (or BIANNUAL) means two per year, with each covering a span of 225-days or less.
- ANNUAL means once per year, not to exceed a span of 15-months.
- BIENNIAL means once every two years, with each covering a span of 30-months or less.
- TRIENNIAL means once every three years, with each covering a span of 45-months or less.

1.3 GENERAL SITE DESCRIPTION

The MFFF site is located adjacent to the Separations Area (existing F Area) of SRS in South Carolina (Figure 1.1-1). SRS, which is owned by the U.S. Government, was set aside in 1950 for the production of nuclear materials for national defense. SRS, as shown in Figure 1.1-1, is an approximately circular tract of land occupying 310 square miles, or 198,400 acres, within Aiken, Barnwell, and Allendale Counties in southwestern South Carolina.

F Area and the MFFF site are located in Aiken County near the center of SRS, east of SRS Road C and north of SRS Road E. The existing F Area comprises approximately 364 acres of SRS. The nearest SRS boundary to F Area is approximately 5.8 miles to the west. The center of F Area is approximately 25 miles southeast of the city limits of Augusta, Georgia; 100 miles from the Atlantic Coast; 6 miles east of the Georgia border; and about 110 miles south-southwest of the North Carolina border. The MFFF site is located adjacent to the north-northwest corner of F Area (Figure 1.1-1).

The largest nearby population centers are Aiken, South Carolina, and Augusta, Georgia. The only towns within 15 miles of the center of SRS are New Ellenton, Jackson, Barnwell, Snelling, and Williston, South Carolina.

Tables

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Table 1.2-1. By-product Material, Source Material, and Special Nuclear Material

Type of Material	Form of Material	Possession Limit
Source Material (Natural and/or Depleted Uranium)	Any chemical or physical form	50,000 kg U
Plutonium, with ≤ 96 wt% ^{239}Pu	Any chemical or physical form	15,000 kg Pu total*
MOX (mixture of UO_2 and PuO_2), with ≤ 22 wt% PuO_2	Any chemical or physical form	400 kg Pu total 1,200 kg U total
MOX, with ≤ 6.3 wt% PuO_2	Any chemical or physical form	15,000 kg Pu total 180,000 kg U total
Enriched Uranium, any enrichment	Any chemical or physical form in unpolished plutonium and waste	100 kg ^{235}U
Plutonium Decay Products, except Uranium	Any chemical or physical form in unpolished plutonium and waste	100 kg
By-product Material	Sealed Sources	200 microcuries with atomic numbers 3 to 83, inclusive
By-product Material	Sealed Instrument Calibration Source	^{252}Cf, 40 curies
By-product Material	Sealed Instrument Calibration Source	^{75}Se, 40 curies
By-product Material	Sealed Instrument Calibration Source	^{239}Pu, 1.3 microgram
By-product Material	Sealed Instrument Calibration Source	^{192}Ir, 40 curies
By-product Material	Sealed Instrument Calibration Source	^{241}Am, 370 Bq
By-product Material	Sealed Instrument Calibration Source	^{235}U, 8000 Bq
By-product Material	Sealed Instrument Calibration Source	^{241}Am, 400 millicuries
By-product Material	Sealed Instrument Calibration Source	^{137}Cs, 10 microcuries

* in Pu feed material; this possession limit does not apply to MOX material, which is specified below.

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Figures

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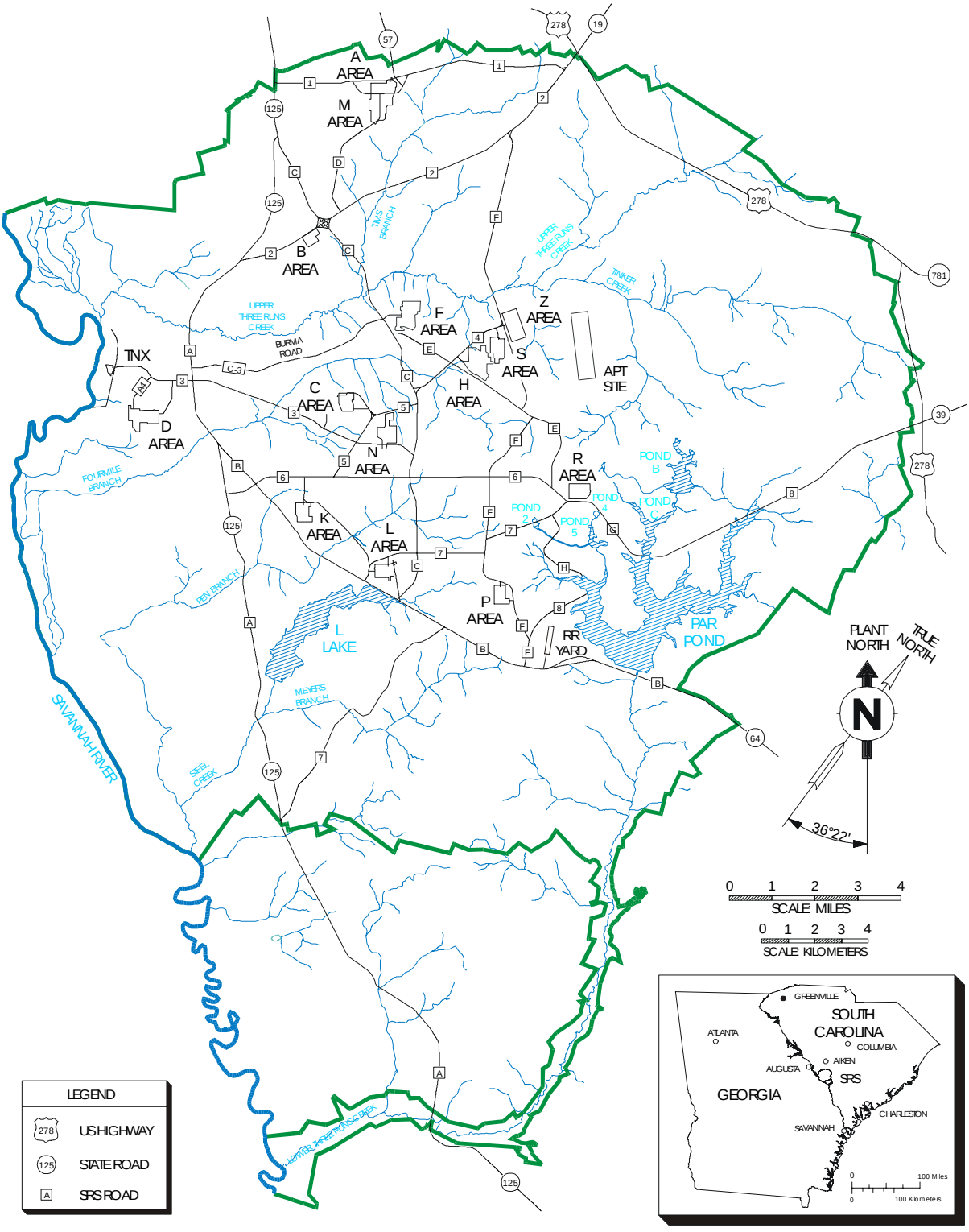

Figure 1.1-1. Location of Savannah River Site and F Area

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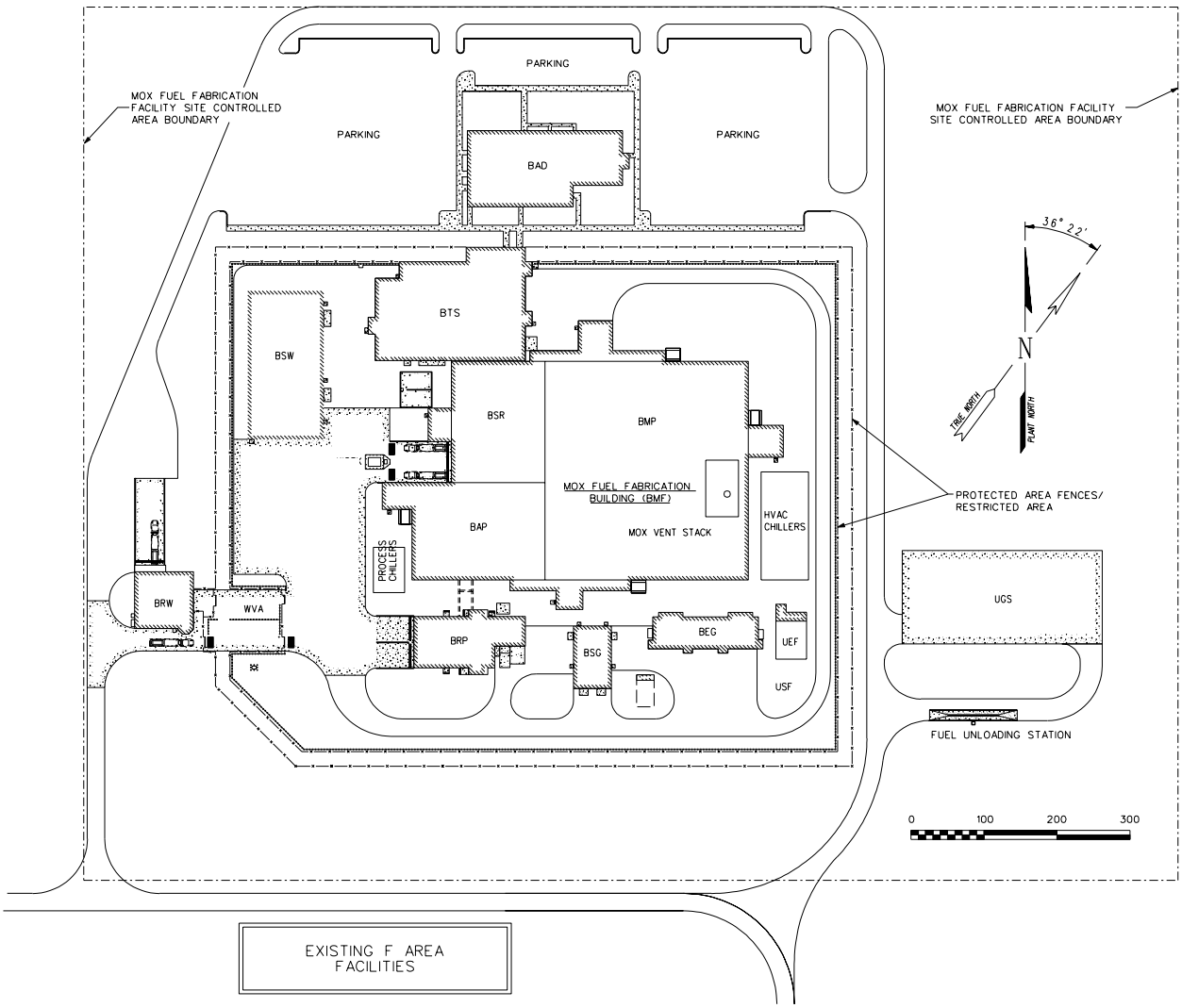

BUILDING LEGEND

MOX FUEL FABRICATION BUILDING (BMF)

BAP – Aqueous Polishing Area
BMP – MOX Processing Area
BSR – Shipping and Receiving Area

SUPPORT BUILDINGS

BAD – Administration Building
BEG – Emergency Generator Building
BRP – Reagent Processing Building
BRW – Receiving Warehouse Building
BSG – Standby Generator Building
BSW – Secured Warehouse Building
BTS – Technical Support Building
UEF – Emergency Fuel Storage Vault
UGS – Gas Storage Area
USF – Standby Diesel Fuel Storage
WVA – Vehicle Access Portal

Figure 1.1-2. MFFF Site Layout

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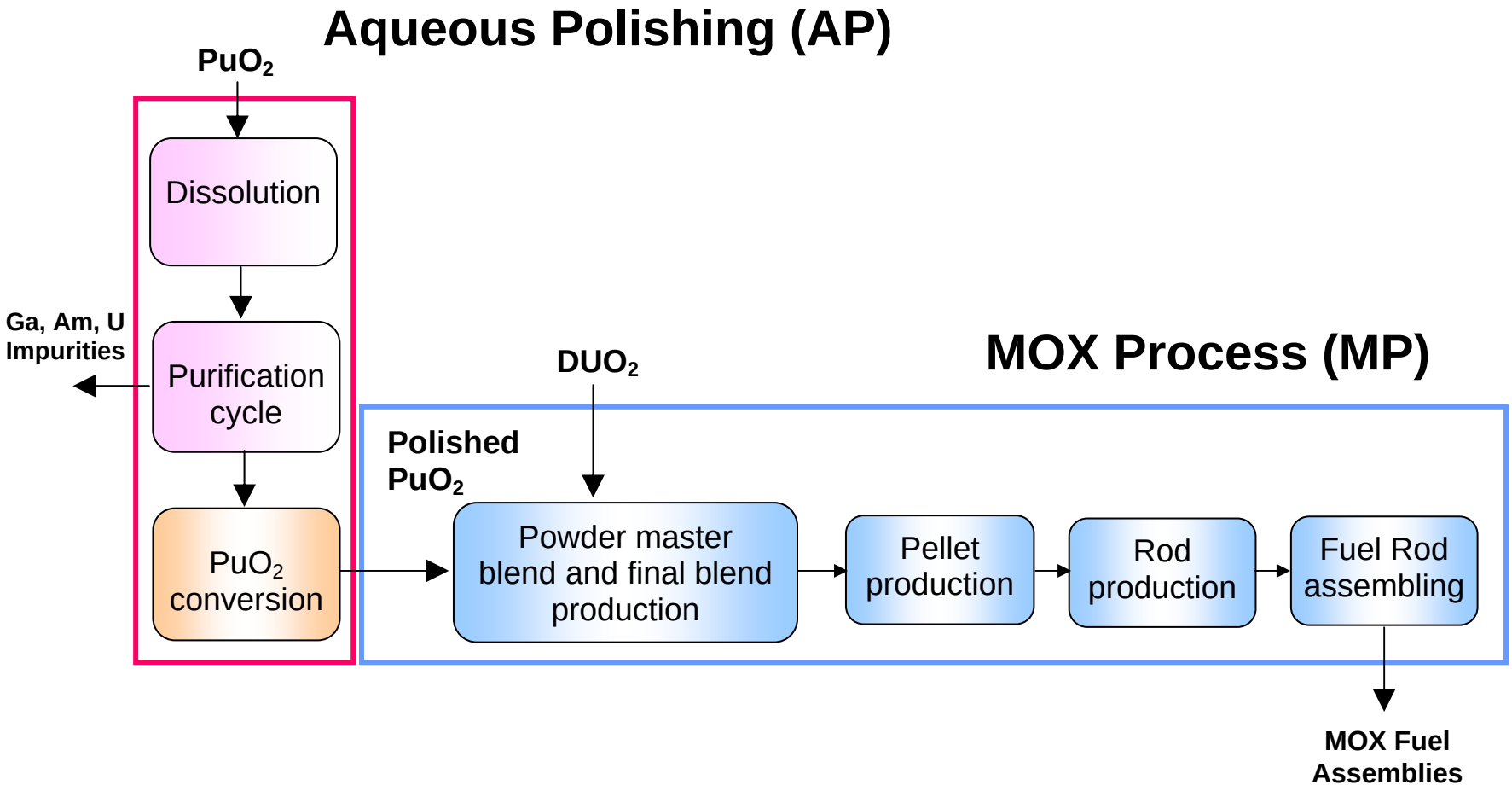

Figure 1.1-3. AP and MP Process Flow Diagram

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2. FINANCIAL QUALIFICATIONS

The purpose of financial qualifications information is to enable the U.S. Nuclear Regulatory Commission (NRC) to determine if the applicant appears to be financially qualified to engage in the proposed activities in accordance with the applicable NRC requirements. The information provided below demonstrates that Duke Cogema Stone & Webster (DCS) is financially qualified to safely operate the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF).

2.1 PROJECT COSTS AND SOURCES OF FUNDS

The United States and the Russian Federation have concluded a bilateral agreement on plutonium disposition, "Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated As No Longer Required for Defense Purposes and Related Cooperation" (September 2000). Under the agreement, the United States will dispose of surplus weapons-grade plutonium. The MFFF is intended to fulfill the United States' obligation for disposition of that plutonium. In light of the MFFF's importance to the United States' obligation and Congressional support for this program, there is significant continuing federal Government incentive to adequately fund the MFFF and to continue providing the necessary annual appropriations to support operation of the MFFF.

DCS operates the MFFF under a contract with the U.S. Department of Energy (DOE). During operations, DOE reimburses DCS for the full cost of operating the MFFF, minus fuel payments that DCS receives from the mission reactor utilities, plus a possible incentive fee. DCS does not intend to finance or rely on the proceeds from debt or equity securities, or any other source of external financing other than DOE funding, nor does it intend to rely on any revenue stream to cover such costs (with the exception of the revenue stream from the mission reactor utilities as described above).

2.2 CONTINGENCY FUNDS

In light of the structure of funding for operations, no contingency funds are necessary. In the unlikely event of a DOE funding shortfall, licensed materials would be placed in a safe condition.

2.3 FINANCIAL QUALIFICATIONS

Because the MFFF is a U.S. Government funded project, the specific financial resources and capabilities of DCS and its equity owners are not relevant to the determination of adequate financial resources to operate the facility. DCS does not intend to rely on its financial resources, or those of an equity partner or parent company, to provide financing.

DCS is not a publicly held entity, and as such, its financial statements are not publicly available. DCS previously submitted under separate cover proprietary financial statements providing information concerning DCS's financial condition.

The structure of DCS reimbursement for MFFF operation is designed to support the MFFF project as a viable business enterprise. Thus, DCS is financially qualified to safely operate the

MFFF, and that financial qualification is supported by the federal Government's obligation through the DOE – DCS contract for the MOX Project.

2.4 LIABILITY INSURANCE

DCS is a DOE contractor and is thus fully covered by DOE nuclear liability protection under the Price-Anderson Act, as amended. Section 170(d) of the Atomic Energy Act provides that the DOE Secretary shall enter into agreements of indemnification with certain persons "... who may conduct activities under a contract with the Department of Energy that involve the risk of public liability and that are not subject to financial protection requirements under subsection b. or agreements of indemnification under subsection c. or k." In accordance with this statutory authority, the contract between DCS and DOE contains the following "Nuclear Hazards Indemnity Agreement" excerpt from Department of Energy Acquisition Regulations (DEAR 952.250-70), which fully indemnifies DCS and its subcontractors up to the statutory limit of liability[1]:

> "(d)(1) *Indemnification*. To the extent that the contractor and other persons indemnified are not compensated by any financial protection permitted or required by DOE, DOE will indemnify the contractor and other persons indemnified against (i) claims for public liability as described in subparagraph (d)(2) of this clause; and (ii) such legal costs of the contractor and other persons indemnified as are approved by DOE, provided that DOE's liability, including such legal costs, shall not exceed the amount set forth in section 170e.(1)(B) of the Act in the aggregate for each nuclear incident or precautionary evacuation occurring within the United States or $100 million in the aggregate for each nuclear incident occurring outside the United States, irrespective of the number of persons indemnified in connection with this contract.
>
> "(2) The public liability referred to in subparagraph (d)(1) of this clause is public liability as defined in the Act which (i) arises out of or in connection with the activities under this contract, including transportation; and (ii) arises out of or results from a nuclear incident or precautionary evacuation, as those terms are defined in the Act."

The DOE indemnity agreement with DCS provides full protection and coverage for public liability arising from operation of the MFFF.

[1] The Energy Policy Act of 2005 (Public Law 109-58; in particular Section 601, Price-Anderson Amendments Act of 2005) increases the limits in the DEAR.

3. PROTECTION OF CLASSIFIED MATTER

Duke Cogema Stone & Webster (DCS) has submitted under separate cover the Classified Matter Protection Plan for the Mixed Oxide (MOX) Fuel Fabrication Facility.

The U.S. Department of Energy (DOE) has rendered a favorable foreign ownership, control, or influence (FOCI) determination of DCS, as discussed in Section 1.2.

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4. ORGANIZATION AND ADMINISTRATION

The Duke Cogema Stone & Webster (DCS) functional organizational structure for the operational phase of the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) is shown in Figure 4-1.

4.1 FACILITY ORGANIZATIONAL STRUCTURE

The DCS functional organizational structure indicates the lines of communication and control of activities for the MFFF. Functional responsibilities and levels of authority are described below for key management functions. The managers responsible for these functions are DCS management personnel with responsibilities for items relied on for safety (IROFS) and related activities.

Qualification requirements for these responsible managers are also provided. Relevant work experience of at least five years, in addition to the minimum experience requirements specified below, may be substituted for educational Bachelor's degree requirements. Where work experience in more than one field is required for a given position (e.g., four years of engineering experience and two years of management experience), the experience may be concurrent unless otherwise indicated. The plant manager has authority to approve exceptions to the qualification requirements for the positions described in this chapter.

4.2 KEY MANAGEMENT FUNCTIONS

4.2.1 Plant Management Function

The manager of the plant is the DCS corporate officer responsible for managing all aspects of the MFFF, including safety and nuclear fuel manufacturing activities at the facility. This individual directs activities of licensed operations and staff functions through designated management personnel. The plant manager provides for the health and safety of the public and workers, and protection of the environment by delegating and assigning responsibility to qualified managers. The plant manager is directly responsible for the following functions: quality assurance, production, regulatory, and support services. These functions are accomplished by delegating and assigning responsibility to qualified personnel.

The minimum qualifications for the plant manager are a Bachelor's degree, or equivalent, in engineering or science, five years of experience in operations and/or engineering of nuclear facilities, and five years of experience in management.

4.2.2 Quality Assurance Function

The manager of the quality assurance (QA) function is responsible for maintaining the DCS MOX Project QA Plan and reports directly to the plant manager. This function is independent of the organizations responsible for performing quality-affecting work and is independent of cost and schedule considerations. This position may be assigned other duties; however, these duties are not allowed to compromise the independence of this function, or to prevent needed attention to quality assurance matters. The manager of the quality assurance function has the same access to the plant manager as the line managers of the various functional areas of the MFFF. This

position is responsible for identifying quality problems, recommending and verifying implementation of solutions, and ensuring that further work is controlled until the unsatisfactory condition has been corrected. The manager of the quality assurance function is responsible for approval of the subcontractor quality assurance programs and oversight and audit functions. These functions are accomplished by delegating and assigning responsibility to qualified personnel.

The minimum qualifications for this position are a Bachelor's degree, or equivalent, four years of quality assurance-related experience, two years of nuclear industry experience, and one year of supervisory or management experience.

4.2.3 Production Function Including the Operations Supervision Function

The manager of the production function is responsible for operational functions, including aqueous polishing and fuel fabrication. This position also is directly responsible for production support functions, such as maintenance, the laboratory, process engineering, and product quality control. These functions are accomplished by delegating and assigning responsibility to qualified supervisors and personnel. The manager of the production function is responsible for the safety and control of operations and is knowledgeable of safety program concepts as they apply to the overall safety of the facility.

The minimum qualifications for this position are a Bachelor's degree, or equivalent, in engineering or science, four years of operational or manufacturing production experience in a nuclear facility, and one year of supervisory or management experience.

The supervisors of the operations functions are responsible for the processing, handling, and storing of licensed materials. Operations supervisors ensure configuration control for the integrated safety of facility processes while meeting production objectives. Operations supervisors accomplish these functions by ensuring that operations personnel are adequately trained and that approved written procedures are available and adhered to. They are knowledgeable of, and responsible for, the control of IROFS within their area of supervision.

The minimum qualifications for these positions are a high school diploma and one year of experience in the nuclear industry.

4.2.4 Regulatory Function

The manager of the regulatory function is independent of the production function and is directly responsible for the following health, safety, and environment, (HS&E) functions: radiation protection, chemical safety, and environmental protection. This function is also responsible for planning and execution of licensing and regulatory compliance activities, including interfaces with regulatory agencies. The manager of the regulatory function is also responsible for safeguards and security, including nuclear material control and accounting. These functions are accomplished by delegating and assigning responsibility to qualified personnel.

The minimum qualifications for this position are a Bachelor's degree, or equivalent, four years of experience in engineering, licensing, or operations of nuclear facilities, and one year of supervisory or management experience.

4.2.5 Support Services Function

The support services function includes those functions necessary to support the MFFF mission. Such support functions include training for employees, plant engineering, finance and accounting, human resources, document control, records management, and procurement. The managers of this function are also responsible for the HS&E functions of fire safety, criticality safety, and safety analysis. Support services functions are accomplished in accordance with DCS policies and procedures.

4.3 ADMINISTRATION

The managers responsible for the above functions are appropriately available to perform their duties; in times of absence, their duties can be delegated to other qualified personnel, as determined by the responsible manager. While these managers have the authority to delegate tasks to other individuals, the responsible manager retains the ultimate responsibility and accountability for compliance with applicable requirements.

Procedures are used to implement HS&E functions associated with the MFFF and management measures that supplement IROFS. See Chapter 15 for a discussion of management measures. These written procedures are formally controlled and approved. If a procedure cannot be adhered to, work is stopped and not resumed until the procedure has been corrected or changed.

Stop-work authority within DCS is vested in each DCS employee, with respect to work within their scope of responsibility, whenever the health and safety of workers, the public, or the environment is involved or when continued work will produce results that are not in compliance with the DCS QA Program. Following a stop-work, activities related to safety are stopped until the deficiency, or unsatisfactory condition, has been resolved. The manager of the regulatory function approves the resumption of activities when satisfied of the effectiveness of the corrective measures.

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Figures

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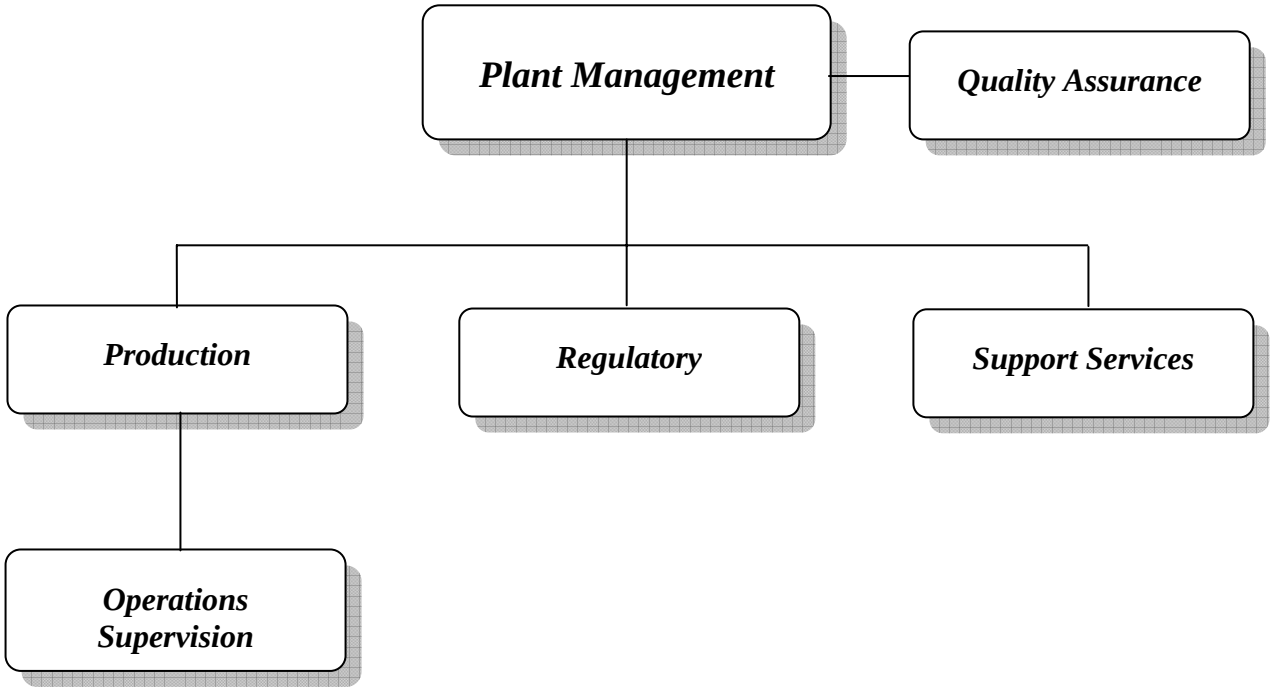

Figure 4-1. MFFF Functional Organization

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5. SAFETY PROGRAM AND INTEGRATED SAFETY ANALYSIS

Duke Cogema Stone & Webster (DCS) has established and maintains a safety program, including an integrated safety analysis (ISA), that demonstrates compliance with the performance requirements of Title 10 of the Code of Federal Regulations (CFR) §70.61.

5.1 SAFETY PROGRAM

The Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) safety program consists of process safety information; an ISA that analyzes MFFF hazards and potential accident sequences, and identifies IROFS; and management measures to ensure that IROFS are available and reliable to perform their function when needed. These three elements of the safety program as described in 10 CFR §70.62 and §70.65 are discussed below.

5.1.1 PROCESS SAFETY INFORMATION

DCS compiles and maintains current written process safety information for the MFFF to identify and understand the hazards associated with the processes, and to update the ISA as required. This information is contained in analyses, specifications, drawings, and other documentation that are prepared, reviewed, and approved in accordance with the MFFF configuration management process (see Chapter 15). Process safety information includes the following:

- A description of the hazards, including information on the pertinent chemical or physical properties of hazardous materials (e.g., toxicity, acute exposure limits, reactivity, thermal and chemical stability, or other applicable information that would typically be included on Material Safety Data Sheets)
- A description of the equipment used in the process (e.g., information of a general nature on such topics as the materials of construction, piping and instrumentation diagrams, ventilation, design codes and standards employed, material and energy balances, safety systems, interlocks, fire detection or suppression systems, electrical classification, relief system design, and the design bases)
- A description of the technology of the process (e.g., block flow or simplified process flow diagrams, a brief outline of the process chemistry, upper and lower limits for controlled parameters, and an evaluation of health and safety consequences of process deviations).

5.1.2 INTEGRATED SAFETY ANALYSIS

An ISA is conducted with an appropriate level of detail for the complexity of the processes involved (10 CFR §70.62(c)). DCS has conducted this ISA to demonstrate compliance with 10 CFR §70.61. The ISA supports preparation of an ISA Summary (as a separate submittal that is not a part of this License Application—as specified by 10 CFR §70.65(b)), a document that summarizes the conclusions of the analyses done as a part of the ISA process. The ISA is a systematic analysis to identify: plant internal and external hazards and their potential for initiating event sequences; the potential event sequences; their likelihood and consequences; and

the structures, systems, and components (SSCs) and activities of personnel that are relied on for safety (i.e., IROFS).

The consequence severity levels that are used in the hazard evaluation are based on 10 CFR §70.61 and are provided in Table 5.1-1. Risk is the product of the event likelihood and consequences. The risk of each credible event is determined by cross-referencing the severity of the consequence of the unmitigated accident sequence with the likelihood of occurrence in a risk matrix. A typical risk matrix that identifies when IROFS are required to be implemented, as a function of the unmitigated event risk and consequences, to satisfy the performance requirements of 10 CFR §70.61 is depicted in Table 5.1-2.

The ISA demonstrates that the IROFS are adequate to perform their intended safety functions when necessary. The ISA is an ongoing process and is maintained during all phases of the life cycle of the facility. DCS has completed an ISA in accordance with the methods and criteria contained in the ISA Summary and the programmatic commitments discussed below. DCS commits to maintaining the ISA.

DCS uses personnel with appropriate experience and expertise in engineering and process operations to perform the ISA. For revisions to the ISA, personnel having qualifications similar to those ISA team members performing the original ISA are used, depending on the nature of the changes.

5.1.3 MANAGEMENT MEASURES

Management measures supplement IROFS by providing the administrative and programmatic framework for configuration management, maintenance, training and qualification, procedures, audits and assessments, incident investigation, and records management. IROFS and appropriate management measures are implemented based on the results of the ISA to ensure compliance with the performance requirements of 10 CFR §70.61. DCS implements and maintains these management measures, as described in Chapter 15, to ensure the required reliability and availability of IROFS.

5.1.4 CONTROL OF FACILITY AND PROCESS CHANGES

DCS maintains the ISA, ISA Summary, and License Application (LA) so that they are accurate and up-to-date by means of the MFFF configuration management processes, which include written procedures. DCS evaluates changes to the facility and its processes for impact on the ISA and LA, and updates the LA and ISA Summary, as needed, in order to ensure their continued accuracy. The evaluation of the facility and process changes includes identification and impact of changes to parameters used in the postulated accident sequences of the ISA (including event likelihood and consequences). Responsibility for maintaining and updating the ISA, ISA Summary, and the LA belongs to the manager of the support services function, as described in Chapter 4.

DCS will address safety-significant vulnerabilities or unacceptable performance deficiencies, if any are identified, in the evaluation of the proposed facility and process changes. DCS will take prompt and appropriate actions to address vulnerabilities that are identified.

DCS controls facility and process changes in accordance with the following requirements:

- A change to the facility or its processes is evaluated, as described above, before the change is implemented. The evaluation of the change determines, before the change is implemented, whether an application for an amendment to the license is required to be submitted in accordance with 10 CFR §70.34.
- The sites, structures, processes, systems, equipment, components, computer programs, and activities of personnel are described in both this License Application and in the accompanying ISA Summary. Pursuant to 10 CFR §70.72, DCS may make changes to these items, as described in the License Application or ISA Summary, without prior U.S. Regulatory Commission (NRC) approval, if the change:
  - Does not create new types of accident sequences that, unless mitigated or prevented, could exceed the performance requirements of 10 CFR §70.61, and that have not previously been described in the ISA Summary;
  - Does not use new processes, technologies, or control systems for which DCS (including its member companies and affiliates) has no prior experience;
  - Does not remove, without at least an equivalent replacement of the safety function, an IROFS that is listed in the ISA Summary;
  - Does not alter an IROFS, listed in the ISA Summary, that is the sole item preventing or mitigating an accident sequence that exceeds the performance requirements of 10 CFR §70.61; and
  - Is not otherwise prohibited by 10 CFR §70.72, license condition, or order.
- If a change allowed under 10 CFR §70.72 is made, the affected onsite documentation will be updated per written procedures.
- DCS maintains records of changes to its facility carried out under 10 CFR §70.72. These records include a written evaluation that provides the bases for the determination that the changes do not require prior NRC approval under paragraphs (b) and (c) of 10 CFR §70.72. These records are maintained until termination of the license.
- Changes are communicated to the NRC as follows:
  - For changes that require NRC pre-approval under 10 CFR §70.72, DCS submits an amendment request to the NRC in accordance with 10 CFR §70.34 and §70.65.
  - For changes that do not require NRC pre-approval of the LA or ISA Summary under 10 CFR §70.72, DCS submits to the NRC annually, within 30 days after the end of the calendar year during which the changes occurred, a brief summary of the changes to the records required by 10 CFR §70.62(a)(2).
  - For changes that affect the ISA Summary, DCS submits to the NRC annually, within 30 days after the end of the calendar year during which the changes occurred, revised ISA Summary pages.

- For changes that affect the LA, DCS submits to the NRC annually, within 30 days after the end of the calendar year during which the changes occurred, revised LA pages.

5.1.5 RECORDS OF FAILURES

Deficiencies in IROFS or failure of management measures are addressed in accordance with the corrective action program described in the MOX Project Quality Assurance Plan (MPQAP). DCS maintains records of failures, readily retrievable and available for inspection by the NRC, documenting each discovery that an IROFS or management measure has failed to perform its function upon demand, or has degraded such that the performance requirements of 10 CFR §70.61 are not satisfied. These records identify the IROFS or management measure that has failed and the safety function affected, the date of discovery, date (or estimated date) of the failure, duration (or estimated duration) of the time that the item was unable to perform its function, other affected IROFS or management measures and their safety function, affected processes, cause of the failure, whether the failure was in the context of the performance requirements or upon demand or both, and corrective or compensatory action that was taken. Failure is recorded at the time of discovery, and the record of failure is updated upon the conclusion of the failure investigation.

5.2 INTEGRATED SAFETY ANALYSIS METHODS

The ISA may be viewed as a developmental process starting with the safety assessment (SA) phase in support of the development of the Construction Authorization Request (CAR) that progressively becomes more sophisticated (i.e., Detailed ISA Phase) in support of the development of the MFFF License Application (LA) and ISA Summary. Initially, a broad set of hazards are identified and analyzed in a general fashion to efficiently identify and evaluate events. Events with either unmitigated consequences satisfying the low dose limits established by 10 CFR §70.61 (i.e., less than "intermediate") or events with event likelihood meeting the requirements of §70.61 (i.e., "not credible" events) are dispositioned and not analyzed further. For the remaining events, progressive layers of more detailed analysis were performed until the risk of identified events satisfied the requirements of 10 CFR §70.61. The ISA is developed, used, and maintained during the life of the facility in accordance with written procedures.

A flow diagram of the ISA process is illustrated in Figures 5.2-1 and 5.2-2. The major steps in the ISA process are as follows:

- Determine internal facility hazards, natural phenomena hazards (NPHs), and external man-made hazards (EMMHs) that could affect the safety of licensed material
- Determine radiological hazards related to possessing or processing licensed material at the facility
- Determine chemical hazards of licensed material, under 10 CFR Part 70, and hazardous chemicals produced from licensed material
- Develop potential events involving internal and external hazards

- Determine the consequence and the likelihood of potential events, and the methods used to determine the consequences and likelihoods
- Determine IROFS and the characteristics of their preventive, mitigative, or other safety function, and the assumptions and conditions under which the item is relied upon to support compliance with the performance requirements of 10 CFR §70.61
- Demonstrate that the IROFS will perform their intended safety functions when necessary
- Prepare the ISA Summary and maintain it during the life of the facility.

The focus of the two phases of the ISA is on the identification of IROFS. The identified IROFS are the necessary and sufficient set of design features and administrative controls (activities of personnel) to be implemented in the final design to satisfy the performance requirements of 10 CFR §70.61. Baseline design criteria, as described in 10 CFR §70.64, are applied from the outset of MFFF design work and are primarily focused on physical design and facility features, with the intent to achieve a conservatively designed facility tolerant of both upsets and human errors. For example, to provide an additional safety margin, reduce challenges to IROFS, and satisfy the requirements of 10 CFR §70.64(b), the MFFF employs defense-in-depth practices from the outset to ensure that multiple layers of risk reduction exist to prevent or mitigate credible event sequences. Although defense-in-depth is a design and operational philosophy that provides additional protection and added assurance that the performance requirements of 10 CFR §70.61 are satisfied, it is not credited in the analyses for meeting 10 CFR §70.61 performance requirements for the associated event sequence.

5.2.1 SAFETY ASSESSMENT PHASE

The Safety Assessment of the Design Basis, shown in Figure 5.2-1, is the first step in the development of the ISA. The SA was completed, and principal SSCs were identified in the CAR. On the basis of the NRC review of the CAR, Construction Authorization No. CAMOX-001(CA) was issued to DCS on March 30, 2005. The technical basis for issuing the CA is documented in NUREG-1821, "Final Safety Evaluation Report on the Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina", issued on the same date as the CA. The CA authorizes DCS to construct a plutonium processing and mixed oxide fuel fabrication plant in accordance with the design bases of the principal SSCs described in the CAR, and the environmental protection commitments presented in DCS' Environmental Report.

5.2.2 DETAILED ISA PHASE

The subsequent detailed phase of the ISA, shown in Figure 5.2-2, builds upon the information and analyses performed as a part of the SA. During the SA phase, the specific analyses necessary to demonstrate compliance with 10 CFR §70.61 were identified. These more detailed analyses have been performed to support development of the LA and ISA Summary. The main purpose of the more detailed analyses is to identify the IROFS at the component level to implement the safety strategy established in the SA. These analyses also demonstrate that the selected IROFS are sufficiently robust to ensure the likelihood criteria of 10 CFR §70.61 are

satisfied. The likelihood of any particular accident sequence relies on the totality of the system of IROFS. Hence, this demonstration considers the entire set of IROFS as well as any supporting management measures and quality assurance (QA) program implemented by this facility to assure the reliability and availability of these IROFS. The following major tasks are performed to support the ISA process:

- Perform Process Hazards Analyses (PrHAs) for each process unit or workshop to support the evaluation of events that must be prevented or mitigated in order to meet the requirements of 10 CFR §70.61. As a part of this analysis, additional analyses that are necessary are identified and assigned for completion.
- Revise, as necessary, the analyses performed in the ISA phase to ensure they remain consistent with the final design. However, if events need to be revised or new hazards or events are identified, the PrHA, Nuclear Safety Evaluation (NSE), and Nuclear Criticality Safety Evaluation (NCSE) processes are used to analyze the hazards and events.
- Prepare NSEs and NCSEs at the event, workshop, process unit, or SSC level, to demonstrate that the system can operate safely under both normal and potential accident conditions. These analyses integrate the necessary analyses and supporting information to demonstrate that the selected IROFS are sufficiently effective, reliable, and available such that the event scenarios satisfy the performance requirements of 10 CFR §70.61.
- Perform design verification activities to ensure that the IROFS identified through the ISA process are appropriately incorporated into the MFFF design and operation.
- Identify the IROFS safety limits/parameters and incorporate into operations.

5.2.2.1 Process Hazards Analyses

PrHAs are performed for each process unit or workshop to identify specific event scenarios in detail, including causes of the events, and associated prevention and mitigation features (IROFS) at the component level. All modes of operation are considered, including startup, normal operation, shutdown, and maintenance. Software malfunctions, including communication and common mode malfunctions and human errors, are included in these analyses. Specific causes evaluated include faults (caused by operation of a support system outside of normal operating ranges) in systems interfacing with the support system in question.

Other event causes evaluated include personnel actions and in-actions (e.g., operator error) that could result in adverse consequences. A detailed review of the various operational sequences was performed to identify process upsets and deviations, including human errors of omission and commission. Manual and semi-automatic processes and sequences were evaluated for potential human errors that could result in adverse consequences. The evaluation of the operational sequences and potential process upsets and causes are documented in the PrHA hazard evaluation tables.

PrHA techniques are process dependent and may include hazard and operability studies (HazOps) and What-If/Checklist analyses. The HazOps and What-If/Checklist studies use the same basic approach and are performed in accordance with the guidance provided in *Guidelines for Hazard Evaluation Procedures – Second Edition – With Worked Examples* (American

Institute of Chemical Engineers, 1992) and NUREG-1513 (*Integrated Safety Analysis Guidance Document,* U.S. Nuclear Regulatory Commission, 1999).

A team leader organizes and distributes technical information to a team of individuals with a variety of backgrounds and experiences. The team meets and together identifies event scenarios, causes, and prevention/mitigation features (IROFS and their safety function) in a step by step manner. As necessary, recommendations are made to modify the design, identify additional analyses to be performed, or actions to be taken to support the identification of the IROFS that are required to satisfy the requirements of 10 CFR §70.61.

In addition, the PrHAs include checklists to identify new hazards associated with changes to the design since the SA was performed. PrHA revisions have the potential to identify new hazards through the use of the checklist analysis method (*Guidelines for Hazard Evaluation Procedures*) that was originally performed in the PHA. For example, a chemical interaction matrix can augment the checklist by identifying any new hazards associated with any new chemicals added to a process. Hence, the PrHAs may identify new event groups associated with newly identified hazards that either were not originally identified by the PHA, or did not exist in the design evaluated by the PHA.

Additional PrHA methods, such as FMEAs, fault tree analyses, and event tree analyses, were used to analyze specific events and processes. Hence, by selecting the appropriate PrHA method, having a sufficient mix of personnel from the appropriate disciplines and with the necessary experience, and performing the PrHA method in a thorough manner, a comprehensive set of event scenarios and IROFS are identified and evaluated.

The PrHAs are living documents and are maintained and revised as necessary during the life of the MFFF project. Revisions to the radiological and chemical consequence calculations are performed, as necessary, to reflect changes in design and other inputs (such as the radioactive material-at-risk – the source material).

Preliminary Hazards Analysis and the Preliminary Accident Analysis have been incorporated into other analyses such as the NSEs and NCSEs. Chemical events that also have the potential to release radioactive material or to affect the safety of licensed material are integrated into the NSEs/NCSEs to demonstrate that they satisfy 10 CFR §70.61 requirements and that the applicable IROFS are sufficiently effective, reliable, and available.

5.2.2.2 Fire Hazards

The Fire Hazards Analysis (FHA) documents the specific fire hazards, the fire protection features proposed to control those hazards, and the adequacy of MFFF fire safety. Three strategies were identified for dealing with fire events: (1) fires that are prevented, (2) fires that cause negligible impact, and (3) fires that are mitigated. The fires that are prevented are analyzed in the PrHAs. The second category, fires that have little or no impact, is demonstrated in fire modeling analyses. Fires that require mitigation are analyzed in heating, ventilation, and air conditioning (HVAC) analyses and the FHA. Each of these analyses are integrated into the NSE/NCSE, as appropriate, to demonstrate that fire events are either highly unlikely or have less

than high consequences, and the IROFS (if any are required) are sufficiently effective, reliable, and available to meet the performance requirements of 10 CFR 70.61.

5.2.2.3 Likelihood Demonstration

To address the likelihood and reliability requirements of 10 CFR 70, the following qualitative definitions are used in assessing the likelihood per event:

- **Not Unlikely** – Events that may occur during the lifetime of the facility
- **Unlikely** – Events that are not expected to occur during the lifetime of the facility or events originally classified as Not Unlikely to which sufficient IROFS are applied to further reduce their likelihood to an acceptable level
- **Highly Unlikely** – Events originally classified as Not Unlikely or Unlikely to which sufficient IROFS are applied to further reduce their likelihood to an acceptable level
- **Credible** – Events that do not meet the definition of "Not Credible"
- **Not Credible** –

  (a) Natural phenomena or external man-made events with an extremely low initiating event frequency, or

  (b) A process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive, and no such sequence of events can ever have actually happened in any fuel cycle facility, or

  (c) Process upsets for which there is a convincing argument, based on physical laws, that are not possible, or are unquestionably extremely unlikely.

These likelihood definitions are described in a manner such that the application of the resulting requirements, which may consist of engineered controls; administrative controls; and management measures, will ensure that the performance requirements of 10 CFR §70.61 are satisfied. These definitions and methodology rely on specific identifiable characteristics of the process design that may affect the likelihood of an accident sequence, rather than subjective judgments of adequacy.

In applying the above definitions to address the performance requirements of 10 CFR §70.61, initiating events are generally assumed to be not unlikely. In most cases, postulated credible intermediate or high consequence events are made highly unlikely based on the application of IROFS features or controls without crediting the likelihood of the initiating event. Accordingly, to ensure that event scenarios with consequences exceeding the low consequence threshold of 10 CFR §70.61 are made highly unlikely, the following approach and commitments are implemented for IROFS:

- Application of the single failure criteria or double contingency (for nuclear criticality)
- Application of 10 CFR 50 Appendix B, NQA-1
- Application of Industry Codes and Standards

- Management Measures, including surveillance of IROFS (i.e., failure detection and repair, or process shutdown capability).

For those credible events where the single failure criteria or double contingency are not applicable (i.e., sole IROFS or passive IROFS feature), IROFS features are identified and the commitments for IROFS listed above are applied. In cases where credit for initiating frequency is required to demonstrate a sequence is highly unlikely, a case by case evaluation is performed and the bases for any initiating event frequency assumptions is justified.

Analyses demonstrate that the likelihood of an event concurrent with the failure of the IROFS satisfy the requirements of 10 CFR §70.61. This is accomplished through the use of a variety of PrHA methods, including qualitative analysis, failure modes and effects analysis (FMEA), or fault tree and event tree analysis, which demonstrate that IROFS are sufficiently reliable and available. The analyses consist of assessing the effectiveness of the IROFS under anticipated accident conditions, and an overall assessment of the event scenario likelihood. Common-mode failure assessments are performed as necessary.

5.2.2.4 Integration of Analyses into the NSEs and NCSEs

The next major step in the ISA process is to integrate the necessary analyses in order to demonstrate that the requirements of 10 CFR §70.61 are satisfied. This includes the results from the PrHAs, FHA, chemical hazards analyses, frequency analyses, deterministic analyses, and criticality analyses. This integration is documented in NSEs (for non-criticality events) and NCSEs (for criticality events). NSEs/NCSEs are prepared at the event, workshop, process unit, or SSC level (depending on the process, SSC, and event being analyzed) and demonstrate that the system can operate safely under normal and event conditions. This demonstration includes identifying the selected safety strategy for each hazard event scenario and the IROFS required to implement the strategy. A description of each IROFS is provided to show that the IROFS is capable of reliably performing its safety function. The conclusions from the NSEs and NCSEs are subsequently included in the ISA Summary.

NSEs/NCSEs are living documents and are maintained and revised as necessary during the life of the MFFF.

5.3 ISA TEAM QUALIFICATIONS

The ISA team for a given process includes a team leader who is knowledgeable in the ISA methodology chosen for the hazard and accident evaluations. In addition, the team leader has an adequate understanding of the process operations and hazards being evaluated. The team includes, as applicable, individuals experienced in hazard identification, hazard evaluation techniques, accident analysis (including consequence assessment), criticality safety, radiation safety, fire safety, and chemical safety. The team possesses operational experience, specific discipline knowledge (e.g., mechanical, electrical, HVAC), and specific knowledge of the processes. In addition, the team has MOX-specific safety analysis experience.

Resources from the following disciplines are used, as appropriate, throughout the ISA process to provide specific expert input:

- Radiochemical process
- Chemical processes (i.e., aqueous polishing)
- Civil/structural/geotechnical
- HVAC
- Glovebox design
- Nuclear (radiological) safety
- Nuclear criticality safety
- Electrical
- Fire protection
- Instrumentation and control
- Mechanical
- MOX fuel process
- Operations
- Radiation protection.

Tables

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Table 5.1-1. Consequence Severity Categories Based on 10 CFR §70.61

Consequence Category	MFFF Facility and Site Workers	IOC	Environment
3: High (H)	TEDE > 1 Sv (100 rem) CC > AEGL3, ERPG3, TEEL3	TEDE > 0.25 Sv (25 rem) CC > AEGL2, ERPG2, TEEL2 ≥30 mg soluble U intake ≥30 mg insoluble U respirable intake	
2: Intermediate (I)	0.25 Sv < TEDE ≤ 1 Sv (25 rem < TEDE ≤ 100 rem) AEGL2, ERPG2, TEEL2 < CC ≤ AEGL3, ERPG3, TEEL3 ≥ 30 mg soluble U intake ≥10 mg insoluble U respirable intake	0.05 Sv < TEDE ≤ 0.25 Sv (5 rem < TEDE ≤ 25 rem) AEGL1, ERPG1, TEEL1 < CC ≤ AEGL2, ERPG2, TEEL2 ≥ 10 mg soluble U intake ≥10 mg insoluble U respirable intake	radioactive release > 5000 x (Table 2 in Appendix B of 10 CFR Part 20)
1: Low (L)	Events of lesser radiological and chemical exposures to workers than those above in this column	Events of lesser radiological and chemical exposures to the IOC than those above in this column	Radioactive releases producing effects less than those specified above in this column

TEDE – Total Effective Dose Equivalent
CC – Chemical Consequences
AEGL – Acute Exposure Guideline Level (1, 2, 3 refers to the severity level)
ERPG – Emergency Response Planning Guideline (1, 2, 3 refers to the severity level)
TEEL – Temporary Emergency Exposure Limits (1, 2, 3 refers to the severity level)

Note: In the calculation of chemical consequences, AEGLs and ERPGs values were not established for many of the MFFF chemicals. Therefore, values issued by the DOE and listed in WSMS-SAE-002-001, Revision 18, are used as quantitative standards for determining the consequence category thresholds. Values in this table include ERPGs and TEELs. For uranium accidents, intakes are used instead of concentration-based TEELs to establish consequence categories.

Table 5.1-2. Typical Event Risk Matrix

CONSEQUENCE	Highly Unlikely (1)	Unlikely (2)	Not Unlikely (3)
High (3)	**3** **No IROFS Applied**	**6** **IROFS Applied**	**9** **IROFS Applied**
Intermediate (2)	**2** **No IROFS Applied**	**4** **No IROFS Applied**	**6** **IROFS Applied**
Low (1)	**1** **No IROFS Applied**	**2** **No IROFS Applied**	**3** **No IROFS Applied**

LIKELIHOOD

Figures

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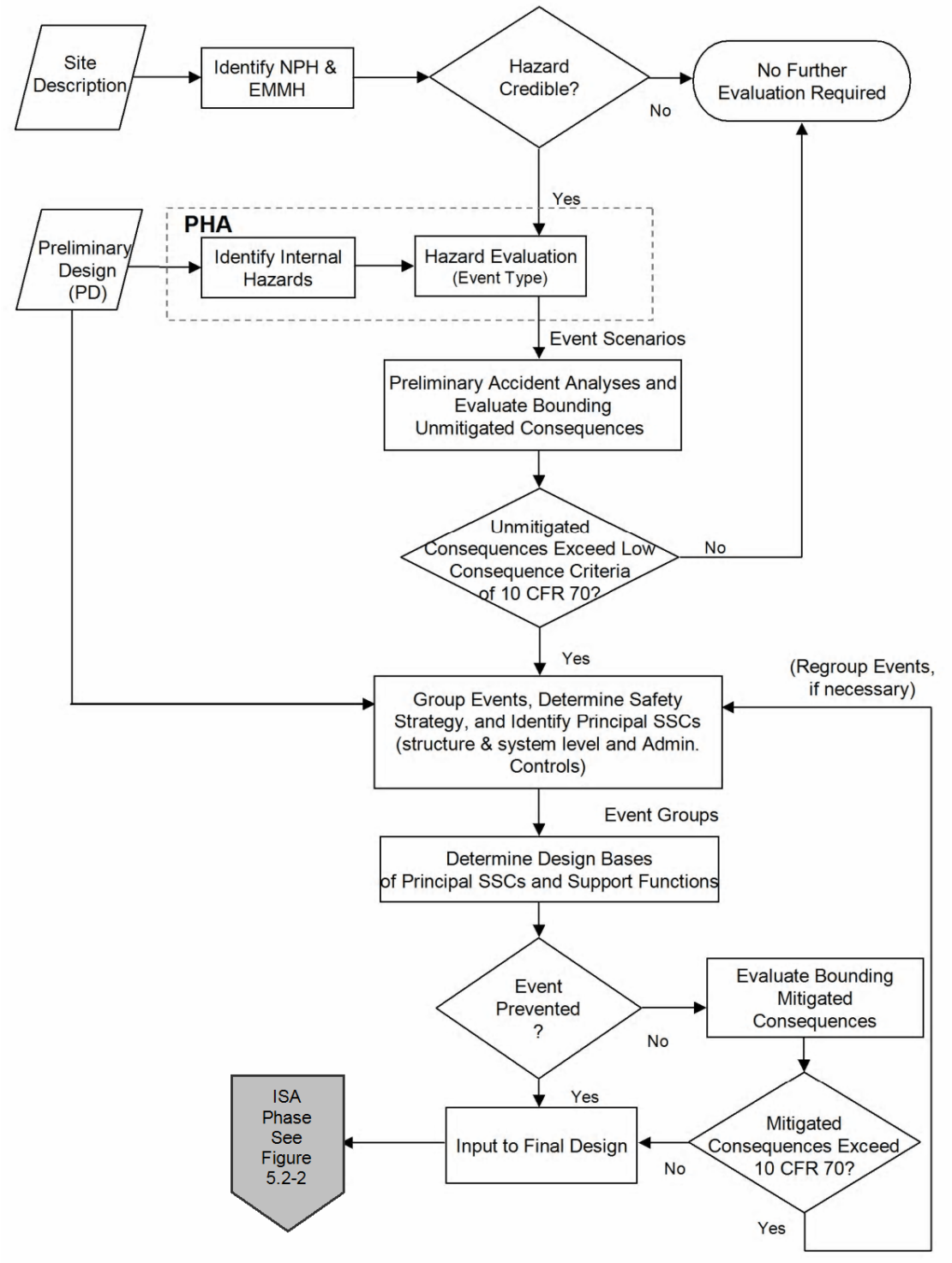

Figure 5.2-1. ISA Process Flow Chart (Safety Assessment)

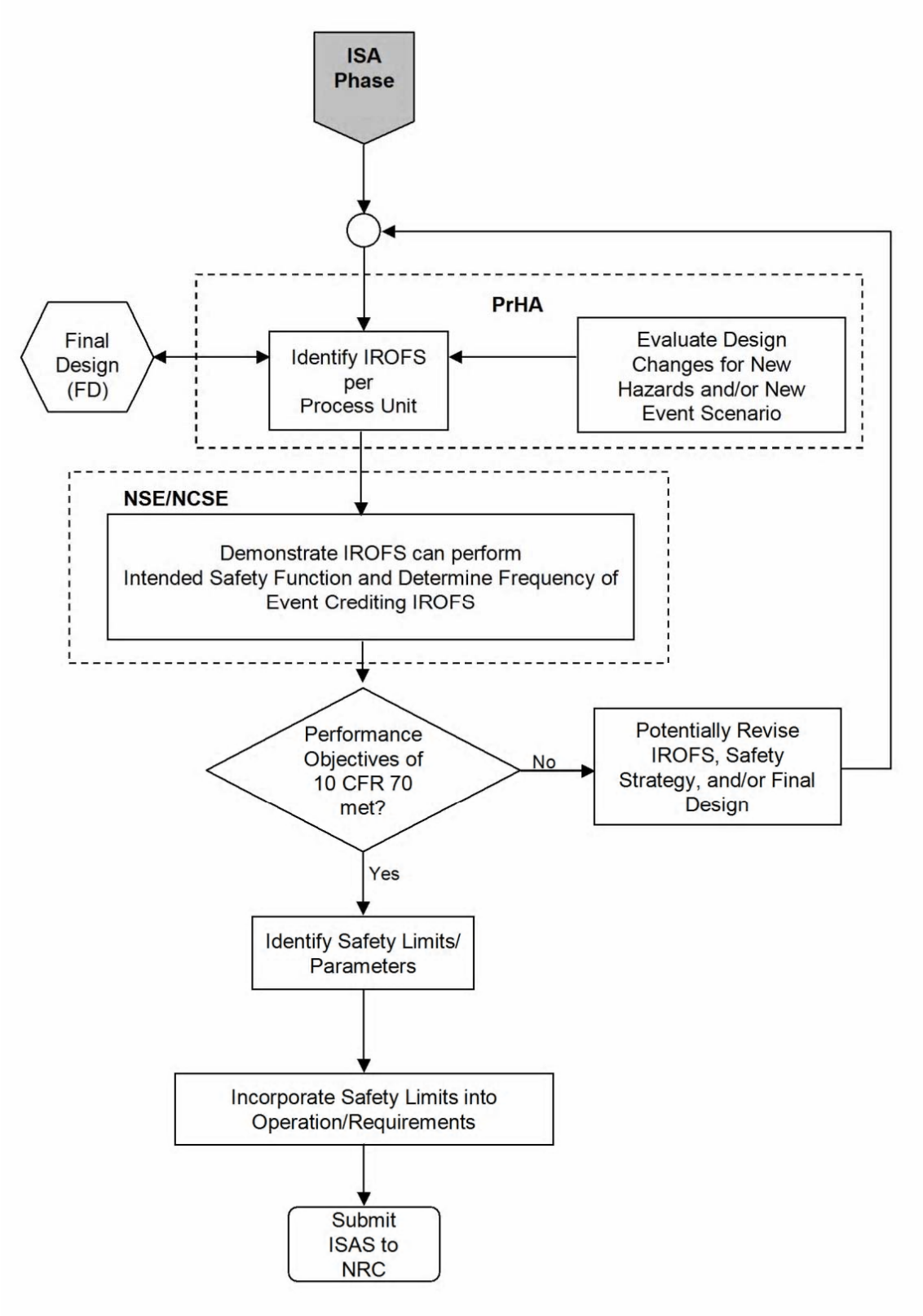

Figure 5.2-2. Process Flow Chart (Detailed ISA Phase)

6. NUCLEAR CRITICALITY SAFETY

As described in this chapter, nuclear criticality safety (NCS) practices for the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) are in accordance with U.S. Nuclear Regulatory Commission (NRC) regulations. The regulations for NCS are found in Title 10 of the Code of Federal Regulations (CFR) Part 70. In addition, MFFF practices for NCS draw, as needed, from guidance contained in Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Materials Facilities*, including American National Standards Institute (ANSI) and American Nuclear Society (ANS) ANSI/ANS 8 national standards.

6.1 ORGANIZATION AND ADMINISTRATION FOR NCS

The MFFF NCS program fosters ownership of nuclear criticality safety by the MFFF organization. The NCS program requires personnel to report defective NCS conditions to the manager of the regulatory function, directly or through a designated supervisor, and requires that the MFFF staff or management take no further action not specified by approved written procedure, until the NCS function has analyzed the situation.

The NCS organization, which reports to the manager of the support services function, is responsible for implementing applicable NCS practices for the MFFF. The NCS organization is independent of operations to the extent practical.

The NCS organization is responsible for implementing NCS practices of ANSI/ANS-8.1-1983 (R1988), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*. The MFFF also implements the administrative practices for nuclear critical safety, as described in ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety*. The manager of the regulatory function and other key management functions are described in Chapter 4.

The NCS organization is administratively independent of production responsibilities, and has the authority and responsibility to shut down potentially unsafe MFFF operations. Specific responsibilities of the NCS organization are to:

- Establish the NCS program, including design criteria, procedures, and training
- Provide NCS support for integrated safety analyses and configuration control
- Assess normal and credible abnormal conditions
- Determine criticality safety limits for controlled parameters
- Develop and validate methods to support nuclear criticality safety evaluations (NCSEs)
- Perform criticality safety calculations and prepare NCSEs
- Review and approve proposed changes in process conditions or equipment involving fissionable material as part of the MFFF configuration management and design change process to determine whether the facility changes require prior NRC approval in accordance with the criteria of 10 CFR §70.72, *Facility Change Process*
- Specify NCS control requirements and functionality

- Review and approve MFFF operations and operating procedures that involve fissionable material
- Support emergency response planning and events
- Assess the effectiveness of the NCS program through the audit/assessment program
- Identify NCS posting requirements that provide administrative controls for operators in applicable work areas
- Maintain NCS programs for the MFFF in accordance with applicable regulatory guides and industry standards
- Be the single point of contact for nuclear criticality issues with internal and external groups or agencies, coordinating with and taking direction from the manager of the regulatory function.

The NCS organization is also responsible for the NCS function for analysis and corrective action. The nuclear criticality process requires that upon identification of a defective NCS condition, the MFFF organization take no further action not specified by approved written procedures, until the NCS function has analyzed the situation. The NCS organization shall be staffed by qualified engineers or technical staff with experience at nuclear facilities involving special nuclear material (SNM).

The manager of the NCS function has the authority and responsibility to assign and direct activities for the NCS function. The minimum qualifications for the manager of the NCS function are a Bachelor's degree in science or engineering, or equivalent, with at least three years of nuclear industry experience in criticality safety. The manager of the NCS function has management or technical experience in the application and/or direction of criticality safety programs for nuclear facilities involving SNM.

A senior NCS engineer has the authority and responsibility to conduct activities assigned to the criticality safety function, as directed by the manager of the NCS function. The minimum qualifications for a senior NCS engineer are a Bachelor's degree in science or engineering, or equivalent, with at least three years of nuclear industry experience in criticality safety.

An NCS engineer has the authority and responsibility to conduct activities assigned to the criticality safety function. The minimum qualifications for an NCS engineer are a Bachelor's degree in science or engineering, or equivalent, with at least one year of nuclear industry experience in criticality safety.

See Chapter 4 for discussion of equivalent relevant work experience that may be substituted for educational Bachelor's degree requirements.

6.2 MANAGEMENT MEASURES FOR NCS

The management practices for MFFF NCS are based on ANSI/ANS-8.1-1983 (R1988), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, which provides guidance on administration, technical practices, validation of calculational methods, and on various acceptable limits for fissile nuclides. MFFF NCS management practices are

implemented in Duke Cogema Stone & Webster (DCS) procedures, and provide reasonable assurance that NCS-related items relied on for safety (IROFS) are available and reliable to perform their designated safety functions when needed. Chapter 15 describes the MFFF management measures implemented to supplement IROFS, including training, audits and assessments, and procedures.

6.2.1 Nuclear Criticality Safety Training

The NCS practices and associated procedures comply with regulatory requirements and subscribe to ANSI/ANS industry standards. DCS endorses the training requirements of both ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety,* and ANSI/ANS-8.20-1991, *Nuclear Criticality Safety Training*. The training is appropriately tailored to the staff's function within the MFFF.

In addition, the MFFF NCS staff develops:

1. NCS training that includes facility, materials, operations, methodologies, design solutions, work stations, and storage locations that provide operators with knowledge and rules to ensure MFFF maintains the nuclear safety margin
2. Instructions regarding the use of process variables for NCS control, when controls on such parameters are credited for nuclear criticality safety (e.g., IROFS)
3. Training that includes the policy to identify NCS posting requirements for administrative controls that provide operators with reference for ensuring conformance and safe operation
4. Training associated with the operation of plutonium containing systems to prevent criticality events.

NCS training is based on ANSI/ANS-8.20-1991, *Nuclear Criticality Safety Training* and is appropriately tailored to the staff's function with the MFFF. NCS training is developed by the NCS organization and implemented in conjunction with the MFFF training function. The instructors of NCS-related material are selected by the manager of the NCS function, in cooperation and coordination with the MFFF training function. Training is on nuclear criticality topics and is performed by the criticality functional organization. The manager of the NCS function ensures that the NCS training is current and adequate and contains the required skills and knowledge, by periodically reviewing training content. Records of currently trained MFFF employees are retained in accordance with the records management program. Visitors are trained commensurate with the scope of their visit and/or are escorted by DCS employees who are fully trained for the scope of the visit, including the criticality safety requirements for the area(s) to be accessed.

6.2.2 Audits and Assessments

DCS utilizes distinct levels of activities to evaluate the effectiveness of the NCS program and other management measures to ensure that operations conform to criticality safety requirements and controls in accordance with ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety*. Internal or external audits, which are independently planned and documented

evaluations, are performed by the quality assurance (QA) organization. Assessments are management directed evaluations, within their area of responsibility, to assess the adequacy, programmatic compliance, and implementation effectiveness of the NCS program and other management measures. Additionally, periodic surveillances and/or walk-downs of areas or activities involving fissile material operations are conducted. The manager of the NCS function, or designee, is lead for NCS assessments, surveillances, and walk-downs. QA audits are consistent with MOX Project QA Plan (MPQAP) requirements. Representatives of the NCS function conduct scheduled assessments, surveillances, and/or walk-downs of applicable MFFF manufacturing and support areas in accordance with approved written procedures.

Quality-affecting activities of the NCS program are evaluated annually by either periodic audits or assessments. As a minimum, regularly scheduled internal audits of the NCS functional area quality-affecting activities shall be performed once every two years. Personnel performing audits shall be independent of the direct responsibility for performing the work being audited. Written notification of a planned audit shall be provided to the functional organization at a reasonable time before the audit is to be performed.

Audit results are communicated in writing to the cognizant management of the audited function/organization. Internal management assessment results identifying findings and recommendations are communicated in writing to the cognizant management having responsibility for the area/activity evaluated and to the manager of the NCS function. Responsible management of the audited function/organization shall complete corrective action(s) including remedial action(s) and action(s) to prevent recurrence and document completion of the action(s) in a timely manner. An extent of condition will also be evaluated where appropriate for findings affecting the NCS function.

6.2.3 Procedures

Procedures and their implementation are reviewed periodically to ensure their continued accuracy and usefulness, and to ensure that procedures are being followed and that process conditions have not changed so as to adversely affect NCS requirements and/or controls. The reviews are conducted, in consultation with operating personnel, by MFFF staff that are knowledgeable in nuclear criticality safety. NCS assessments, surveillance, and walk-downs of the operating MFFF SNM process areas are conducted periodically. The manager of the NCS function may utilize a risk-informed methodology determination based upon the compliance results of these evaluations, to increase or decrease the scheduled frequency of these reviews or the scope of the evaluations. The evaluations are documented (e.g., by a checklist). Identified weaknesses are incorporated into the MFFF Corrective Action Program, and are promptly and effectively resolved.

6.2.4 NCS Procedures

Procedures are established and implemented for nuclear criticality safety in accordance with ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety*. NCS posting requirements at the MFFF are established that identify administrative controls applicable and appropriate to the activity or area. NCS procedures and postings are controlled to ensure that they are maintained current.

6.2.5 Change Management

The NCS functional organization shall review proposed changes to structures, systems and components (SSCs), hardware, software, processes and procedures to ensure that proposed facility changes are managed to maintain the integrity of the facility's safety basis and to ensure that proposed changes receive the appropriate level of NCS review. The NCS review assures that the ability of the NCS credited SSCs and/or IROFS to perform their function when needed is maintained. The NCS functional organization reviews and approves proposed changes in process conditions or equipment involving fissionable material as part of the MFFF configuration management and design change process to determine whether the facility changes require prior NRC approval in accordance with the criteria of 10 CFR §70.72, *Facility Change Process*.

6.3 NUCLEAR INCIDENT MONITORING SYSTEM

The purpose of the nuclear incident monitoring (NIM) system is to reduce risk to personnel by providing prompt warning and notification should a nuclear criticality event occur. The design and operation of the NIM system also takes into consideration the avoidance of false alarms. Alarm actuation setpoint(s) are specified with consideration of normal operating background radiation levels such that spurious actuations from sources other than criticality do not occur. The NIM system monitors MFFF areas in which SNM is handled, used, or stored.

In the highly unlikely event of a nuclear criticality, the NIM system is intended to:

- Monitor for excessive gamma and neutron equivalent radiation
- Monitor appropriate areas
- Warn personnel as quickly as possible.

The NIM system, which utilizes both fixed and portable monitoring units, is designed in accordance with generally accepted practices and those required by 10 CFR §70.24. ANSI/ANS-8.3-1997, *Criticality Accident Alarm System*, is the guidance document that defines the design criteria and functional operation requirements of the NIM system (or criticality accident alarm system). These features assure detection capability and prompt notification by audible alarm, visual light, or other notification means to warn personnel of a criticality condition. Criticality monitoring is performed by groups of detectors called "monitoring units." Redundant NIM system monitoring units provide overlapping detection coverage for the defined area of coverage. Additionally, each NIM system monitoring unit contains multiple gamma detectors that provide a redundant detector actuation logic thus minimizing false alarms. The data from the NIM system monitoring units is sent real time to the emergency control consoles. Audible alarms, visual lights, or other notification means are provided.

If the NIM system, detection or alarm/notification capability, becomes unavailable, the allowable number of hours during which NIM system coverage is not available is determined on a process-by-process basis. The MFFF will maintain safe operations by implementing compensatory measures (e.g., limit personnel access, halt SNM movement or activities) as necessary when the NIM system is unavailable or significantly degraded.

The evaluation of the effectiveness of NIM system detectors (detection criteria and location/spacing) takes into account the effect of existing shielding. NIM system detector coverage radius is determined through the use of three dimensional radiation transport codes.

6.3.1 NIM System Principles of Operation

The NIM system is designed to detect radiation in the highly unlikely occurrence of a criticality event. The nuclear criticality audible alarm, visual light, or other notification means are provided in locations normally occupied by MFFF personnel and in close proximity outside the building. Indication that a NIM system alarm condition has occurred is also sent to an emergency control console in the control room and/or a remote facility. The criticality alarm is designed to accommodate the working environment within the MFFF.

6.3.2 NIM System Design

NIM system design features:

- Prevent spurious alarms through the use of redundant detectors and alarm actuation setpoint determination
- Produce event records through the use of the Emergency Control Consoles.

The design criteria for the NIM system are:

- **Reliability** – NIM system components do not require frequent servicing. The system is designed to reduce the effects of non-use, deterioration, power surges, and other adverse conditions. The design ensures reliable actuation of an alarm, while avoiding false alarms.
- **Seismic tolerance** – The NIM system is designed to remain operational in the event of a seismic shock equivalent to the MFFF design basis earthquake.
- **System vulnerability** – NIM system components are protected in order to reduce the potential for damage in case of fire, explosion, corrosive atmosphere, or other probable extreme conditions. The system is designed to reduce the potential of failure, including false alarms.
- **Failure warning** – The NIM system provides a visual or audible warning signal to indicate system malfunction or the loss of primary power.
- **Response time** – The NIM system produces a criticality alarm signal within one-half second of detector recognition of a criticality event.
- **Detection** – The NIM system is designed to detect the minimum event of concern. In areas where fissionable material is handled, used, or stored, the minimum event of concern is analytically determined based on the process, materials, geometry, and process equipment present in each covered area. The minimum event of concern delivers the equivalent of an absorbed dose in soft tissue of 20 rads of combined neutron and gamma radiation at an unshielded distance of 6.6 feet, within one minute.

- **Spacing** – NIM system detector spacing is consistent with the alarm trip point and the detection criterion above. The location and spacing of detectors are chosen to account for the effect of shielding by equipment or materials.
- **Electrical power –** The normal alternating current (AC) power system supplies 120-VAC electrical power to the NIM system. The standby power system through the 120-VAC emergency power supply will automatically power the NIM system in the event of loss of normal AC power.
- **Staff emergency response** – The nuclear criticality accident onsite emergency planning and response for the MFFF staff follows the guidance in ANSI/ANS 8.23 1997, *Nuclear Criticality Accident Emergency Planning and Response*. (As described in Chapter 14, an emergency plan is not required to be submitted.)
- **Emergency procedure** – The MFFF staff maintains an emergency procedure, which covers the entire facility including locations where licensed SNM is handled, used, or stored, to ensure that personnel can be withdrawn to a safe area upon the actuation of the NIM system alarm notification.

6.4 NCS TECHNICAL PRACTICES

6.4.1 Nuclear Criticality Safety Evaluations

When an MFFF component or system is designed or modified, an NCSE is developed or updated to determine that the entire process will be subcritical under both normal and credible abnormal conditions.

NCSEs are documented with sufficient detail and clarity to allow independent review and approval of results, and to explicitly identify the controlled nuclear and process parameters, and the associated limits on which nuclear criticality safety depends.

An evaluation is performed to determine credible event sequences and identify controls such that double contingency protection is provided. The evaluation may include criticality calculations using validated calculational methodologies to demonstrate that both normal and credible abnormal conditions meet the required minimum margin of subcriticality. IROFS are identified in the NCSE. Features that ensure that the criticality controls identified in the NCSE are sufficiently available and reliable are provided through implementation of management measures such as: procedures, training, maintenance procedures, and surveillance. The NCSE provides documentation that demonstrates that potential credible events are highly unlikely to cause a criticality.

6.4.2 Analytical Methodology

The double contingency principle specified in 10 CFR §70.64(a)(9) and ANSI/ANS-8.1-1983 (R1988), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors* requires that the process incorporates sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality event can occur. NCSEs of the design of the MFFF demonstrate compliance with the double contingency

principle and the adequacy of criticality controls. The NCSEs, which are part of the integrated safety analysis (ISA), identify the assumptions used in the criticality evaluations. The evaluations of the assumptions are based on realistic processes; conservative assumptions are analytically quantified so as to demonstrate the level of conservatism added. The ISA also documents a comprehensive systematic review of MFFF hazards in Process Hazards Analysis (PrHAs), including criticality, and provides additional confirmation of the acceptability of the selected means of criticality control.

Compliance with the double contingency principle is demonstrated by identifying two or more controls on which reliance is placed to ensure criticality safety. Common mode failures and the potential interaction between units containing fissionable material are appropriately taken into account. In addition to providing a basis for identifying IROFS, the hazard identification and review processes documented in the ISA are used to promote defense-in-depth practices in MFFF design and layout. Defense-in-depth practices are incorporated in the MFFF, such as the preferential selection of first passive engineered controls, secondly active engineered controls, and then administrative controls, where practical.

Acceptance criteria applied in performing double contingency and criticality hazard assessments are summarized as follows:

- When applying a single control to maintain limits on two or more controlled parameters, credit is taken for a single component only, for double contingency compliance.
- No single credible event or failure will result in a criticality.
- Geometry control constitutes the preferred controlled parameter, with fixed neutron absorbers employed as necessary.
- Where practical, reliance is placed on equipment design that uses passive engineered controls, rather than on administrative controls.
- Controlled parameters are identified in the NCSE evaluations. IROFS associated with maintaining these controlled parameters are noted in the NCSE. The criticality safety controlled parameters are transferred into appropriate operating and maintenance procedures.
- Evaluations based on realistic component parameters are performed to demonstrate that controlled parameters are maintained during both normal and credible abnormal conditions. Summaries of these evaluations are provided in the NCSEs. In cases where controlled parameters are controlled by measurement, reliable methods that ensure representative sampling and analysis are used.

6.4.3 Additional Technical Practices

A design application (system) for an MFFF unit is considered subcritical when the calculated multiplication factor for the design application (system) (ANSI/ANS-8.17 Section 5 [1984], *Criticality Safety Criteria for the Handling, Storage, and Transportation of Light Water Reactor (LWR) Fuel Outside Reactors*) is shown to be less than or equal to an established maximum allowed value that properly accounts for method bias, including appropriate processes, and

uncertainty and administrative margin. An administrative margin of 0.05 is used for MFFF design applications. See Section 6.4.5 for discussion of the upper safety limit (USL) for each MFFF area of applicability (AOA).

6.4.4 Criticality Control Modes

Criticality control modes are the methods of criticality safety control selected for various MFFF process stations and areas. Reliance is initially placed on equipment design using passive engineered controls, rather than administrative controls, where practical. Techniques for criticality control, listed in order of preference, are:

- **Passive Engineered Controls** – Controls that employ permanent and static design features or devices to preclude inadvertent criticality. No human intervention is required, except for maintenance and inspection.
- **Active Engineered Controls** – Controls that use active hardware to sense conditions and automatically place a system in a safe state or mode. Actuation and operation of these controls do not require human intervention.
- **Enhanced Administrative Controls** – Controls that rely on human judgment, training, and actions for implementation, and employ active warning devices (audible or visual) that prompt specific human actions to occur before the process can exceed established limits.
- **Simple Administrative Controls** – Controls that rely solely on human judgment, training, and actions for implementation.

The MFFF uses controls of hierarchical preference, to the extent practical, to provide correspondingly higher reliability when assessing criticality risks and demonstrating compliance with the double contingency principle.

To ensure criticality control in activities involving significant quantities of fissionable materials, one or several of the following available control modes are used:

- Geometry Control
- Mass Control
- Density control
- Isotopic control
- Reflection control
- Moderation control
- Concentration control
- Interaction control
- Neutron absorber control
- Volume control
- Heterogeneity control
- Physicochemical control
- Process variable control.

Geometry control constitutes the preferred control mode, with fixed neutron absorbers employed as necessary. Although geometry control is preferred, several methods of criticality control are employed in the aqueous polishing (AP) and MOX processing (MP) designs.

Controlled parameters and techniques for controlling associated modes to minimize the risk of inadvertent criticality are established and justified. Tolerances on controlled parameters are conservatively taken into account in establishing operating limits and controls. The potential for neutron interaction between units is evaluated to ensure that the process remains subcritical under normal and credible accident conditions. Additional controls on spacing are identified as IROFS as necessary. MFFF management measures described in Chapter 15 are generally required to ensure double contingency compliance.

6.4.4.1 Geometry Control

Geometry control involves the use of passive engineered devices to control worst-case geometry within ensured tolerances. Geometry parameters are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Geometry control is used in MFFF design wherever possible, including the following design applications:

- For storage systems containing large quantities of fissile material (for which mass or mass and moderation control is not applicable)
- For process equipment whenever the imposed geometry is compatible with the applicable process function.

When the possibility of neutron interaction with other fissile units exists, interaction control or neutron absorber control may also be indicated, in conjunction with geometry control.

Geometry control parameter limits are established and implemented as follows:

- Dimensions and nuclear properties of MFFF features relying on geometry control are subject to QA measures during design and fabrication, and are verified prior to beginning operations. The MFFF configuration management program (see Chapter 15) is used to maintain these dimensions and nuclear properties.
- Credible means of transferring fissile materials to an unfavorable geometry are identified and evaluated, and controls (i.e., IROFS) are established to ensure that such transfers are precluded. In particular, leaks from favorable-geometry process vessels are collected in favorable-geometry drip trays.
- Tolerances on nominal design dimensions are treated conservatively.
- Possible mechanisms for changes to fixed geometry are evaluated, and controls are established as necessary. Credible mechanisms that could result in component deformation or changes in geometry are identified and evaluated. Where such credible mechanisms exist, applicable design allowances and/or the surveillance program are specified.

6.4.4.2 Mass Control

Mass control involves the use of mass-based, single-parameter limits established on conservative geometry (i.e., spherical) and SNM form (e.g., metal, oxide, aqueous solution), unless these parameters are controlled by IROFS (i.e., implementation of another criticality control mode(s) in addition to mass control). Single-parameter limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being inadvertently exceeded) using documented and approved methods, standards, or handbooks. Mass control is used in MFFF design applications where the process function is not compatible with geometry control. Mass control is generally used in combination with moderation control (i.e., allowable mass with moderation control is higher than without moderation control). The mass is generally controlled through a process variable control (i.e., required process controls include weighing and material mass balance functions). When the possibility of neutron interaction with other fissile units exists, interaction control or neutron absorber control may also be indicated, in conjunction with mass control.

Mass control is available as a control mode where the limitation of mass is compatible with the process function and where mass can be reliably controlled during process operations (e.g., by direct weighing and/or mass balances).

Mass control parameter limits are established and implemented as follows:

- Mass limits are derived for a material that is assumed to have a given weight percent of SNM, based on conservative assumptions. Determinations of mass are based on either (1) weighing the material and assuming the entire mass is SNM, or (2) taking physical measurements to establish the actual weight percent of SNM in the material. When process variables can affect the bounding weight percent of SNM in the mixture, the SSCs or procedures that affect the process variables are evaluated.
- Theoretical densities for fissile mixtures are used, unless lower densities are ensured, or data are available.
- Reasonable batch sizes are considered:
  - When overbatching of SNM is possible, the mass of SNM in a single batch is limited so that the mass of the largest overbatch resulting from a single failure is safely subcritical, taking system uncertainties into account. Overbatching beyond double batching is considered when the unit allows additional material to be accepted, to establish the margin of safety.
  - When overbatching of SNM is not possible, the mass of SNM in a batch is limited to be safely subcritical, taking system uncertainties into account.
- Mass limits are established taking tolerances into account. The determination of minimum critical mass is based on spherical geometry, unless actual fixed geometry is controlled.
- Instrumentation used to physically measure mass is subject to QA controls.

Establishing a mass limit involves consideration of potential moderation, reflection, geometry, spacing, and material concentration. The evaluation considers normal operations and expected process upsets for determination of the actual mass limit for the system and for the definition of subsequent controls.

6.4.4.3 Density Control

Density control involves taking credit for controls on SNM density in which non-optimal SNM density characteristics are used in the performance of criticality safety design calculations. SNM density limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being inadvertently exceeded) using documented and approved methods, standards, or handbooks. Density control is used in the MFFF design, where the process function is not compatible with a worst-case SNM density assumption (i.e., maximum theoretical density), and is generally used in combination with mass, geometry, and/or moderation control.

Density control parameter limits are established and implemented as follows:

- Conservative assumptions are made about the density of the fissile material.
- Instrumentation used to physically measure density is subject to QA controls.
- When process variables can affect the density, controls to maintain the process variables are identified as IROFS in the related NCSE.

6.4.4.4 Isotopic Control

Isotopic abundance control involves taking credit for established realistic or conservative assumptions regarding SNM isotopic abundance in the performance of criticality safety design calculations. Isotopic control includes both the $^{235}U/U$ concentration (enrichment) and the concentration of fissile and nonfissile plutonium isotopes (e.g., ^{239}Pu, ^{240}Pu, ^{241}Pu), as well as the relative abundance of plutonium to uranium. The presence of ^{240}Pu (5% to 9%) and ^{242}Pu (<0.02%) offsets the contribution from ^{241}Pu (<1%), such that their presence can be neglected for ^{239}Pu in the range from 90% to 95%, as is expected to be the case for the MFFF. This will be demonstrated in the criticality calculation to be referenced in the NCSEs. Justification will be provided in the NCSEs. SNM fissile and neutron absorption isotope abundance limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks.

Isotopic control parameter limits are established and implemented as follows:

- When taking credit for isotopic mixtures (where different isotopic mixtures could coexist), controls are established to segregate clearly labeled SNM of different isotopic mixtures. In addition, the determination of isotopic content is based on compliance with the double contingency principle. Consideration is given to sample analysis and verification activities associated with MFFF and vendor (DOE)-supplied measurements. DOE (PDCF) and vendor data are qualified in accordance with an approved QA plan and

are audited by the MFFF QA function. The use of qualified nondestructive assay (NDA) measurement systems is also acceptable in establishing compliance with the double contingency principle.

- Instrumentation used to physically measure isotopics is subject to QA controls.

6.4.4.5 Reflection Control

Reflection control involves the control of fissile unit geometry and the presence of neutron-reflecting materials in process areas to increase neutron leakage from a subcritical fissile system and thereby reduce the calculated subcritical multiplication factor for the system. Although reflection control is generally applied as a passive engineered feature (i.e., configuration of concrete walls or the construction of fixed personnel barriers), reflection control generally also requires surveillance procedures to ensure that neutron-reflecting materials are excluded from the process area, or to confirm continued efficacy of personnel barriers.

Reflection control parameter limits are established and implemented as follows:

- When determining subcritical limits for an individual unit, the wall thickness of the unit and reflecting adjacent materials of the unit are conservatively bounded by the assumed reflection conditions, leaving allowances for transient reflectors as discussed below.
- Sufficient water reflection is conservatively used in evaluations to simulate potential personnel and/or other transient reflectors.
- In cases where loss of reflection control can lead to criticality, by itself or in conjunction with another single failure, rigid and testable barriers are established and maintained by MFFF management measures (i.e., configuration management and maintenance programs) described in Chapter 15.
- In cases where reflection control is not indicated, water reflection of process stations or fissile units is represented by a tight-fitting water jacket, unless consideration of other materials present in the design (e.g., concrete, carbon, or polyethylene) may be a more effective, more conservative assumption, than water.
- Conservative reflection conditions are established when evaluating the criticality safety of arrays. For example, conservative minimum distances from arrays to reflecting materials are established (e.g., concrete or water).

6.4.4.6 Moderation Control

Moderation control involves taking credit for non-optimal SNM moderator content or presence within process equipment or areas, in the performance of criticality safety design calculations. SNM moderator content limits or exclusion controls for areas are established in a manner that ensures a conservative margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Moderation control is used in MFFF design applications where the process function is not compatible with a worst-case SNM moderator content (i.e., optimum moderation) or process/storage area flooding assumption. Moderation

control is generally used in combination with mass or geometry control. Moderation control sometimes requires process variable control or other surveillance activities.

Moderation control is particularly useful in situations where process capacity requirements are not satisfied using mass control alone, and where the level of moderation is easily bounded or controlled (e.g., equipment in the powder handling stations confined within gloveboxes).

Potential sources of moderation that are considered include:

- Residual humidity present in powders
- Organic additives (e.g., lubricant, poreformer) used as part of a process
- Moderating fluids (e.g., water or certain oils), which could potentially enter process stations or storage areas under normal or abnormal conditions
- Presence of polyethylene, particularly in waste handling units.

Certain moderators (e.g., humidity and organic additives) exist during normal operations. Criticality safety calculations employ assumptions or process information to account for moderators normally anticipated being present in processes (see below). Moderation control parameter limits are established and implemented as follows:

- Moderation control is implemented consistent with guidance provided in ANSI/ANS-8.22-1997, *Nuclear Criticality Safety Based on Limiting and Controlling Moderators*.
- When process variables can affect moderation, the SSCs or procedures that affect those process variables are defined as IROFS.
- Physical structures credited with performing moderator exclusion functions are designed to preclude ingress of moderator.
- When sampling of moderation properties is required, the sampling program is based on compliance with the double contingency principle.
- Consideration is given to sample analysis and verification activities associated with MFFF and vendor-supplied measurements. Vendor data are qualified in accordance with an approved QA plan and are audited by the MFFF QA function. The use of qualified NDA measurement systems is also acceptable in establishing compliance. The sampling process incorporates independent verification as part of the sampling and analysis program.
- Fire protection system design, and fire-fighting procedures and training programs are developed with appropriate restrictions placed on the use of moderating materials. The effects of credible fire events and the consequences associated with the potential use of moderating material in mitigating such fires are evaluated, as applicable.
- Credible sources of moderation are identified and evaluated for potential intrusion into moderator-controlled process stations or areas, and the ingress of moderator is precluded or controlled.

- The effects of varying levels of credible interstitial moderation are evaluated when considering neutron interaction between physically separated fissile units.
- Instrumentation used to physically measure moderators is subject to QA controls.
- Drains are provided to prevent water accumulation, if that accumulation could lead to unfavorable configurations of fissile material.

6.4.4.7 Concentration Control

Concentration control involves the use of concentration-based single-parameter limits established based on conservative case geometry (i.e., spherical) and SNM fissile composition, unless these parameters are controlled by IROFS (i.e., implementation of another criticality control mode(s) in addition to concentration control). Concentration control is generally applied to process equipment handling solutions with low fissile material concentration. Single-parameter limits for concentration are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables), using documented and approved methods, standards, or handbooks. Concentration control typically includes process variable control to ensure that concentration limits are not exceeded.

Concentration control parameter limits are established and implemented as follows:

- When process variables can affect the concentration, those process variables are defined and controlled.
- Concentrations of SNM in excess of controlled parameter limits are precluded.
- When using a tank containing concentration-controlled solution, access to the tank is controlled. When sampling of the concentration is specified, the sampling program uses independent verification sampling methods.
- Concentration-controlled processes are designed and operated in a manner that ensures that possible precipitating agents are not inadvertently introduced to the process, or that the effects of precipitation are taken into account.
- Instrumentation used to physically measure concentration is subject to QA controls.
- Concentration-controlled processes are designed and operated in a manner that prevents overconcentration in excess of controlled parameter limits.

6.4.4.8 Interaction Control

Interaction control involves the use of spacing to limit neutron interaction between fissile units. When interaction control is employed using passive engineered features (e.g., fuel assembly storage racks), interaction control is considered equivalent to geometry control in terms of hierarchical preference.

When neutron absorbers are used to limit interaction between fissile units, neutron absorber control is indicated in lieu of interaction control.

Interaction control parameter limits are established and implemented as follows:

- When maintaining physical separation between units, passive engineered features (i.e., spacers or other passive geometrical means) are used to the extent practical. The structural integrity of such engineered features is sufficient for normal and design basis conditions.
- When unit spacing is controlled by procedure, it is demonstrated that multiple procedural violations do not by themselves lead to criticality.
- When evaluating the criticality safety of units in an array or pairs of arrays, the spacing limits in ANSI/ANS-8.7-1975, *Guide for Nuclear Criticality Safety in the Storage of Fissile Materials* are used, or spacing is based on validated calculational methods.

6.4.4.9 Neutron Absorber Control

Neutron absorber control involves the use of supplemental neutron absorber features to limit subcritical multiplication of a single fissile unit (e.g., cadmium coatings and borated concrete), or to limit neutron interaction between multiple (spaced) fissile units. When using fixed neutron absorbers, MFFF design and procedural controls are implemented consistent with guidance provided in ANSI/ANS-8.21-1995, *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors*.

6.4.4.10 Volume Control

Volume control involves the use of volume-based single-parameter limits established based upon worst-case geometry (i.e., spherical) and SNM form (e.g., metal, oxide, aqueous solution), unless these parameters are controlled by IROFS (i.e., implementation of another criticality control mode(s) in addition to volume). Single-parameter limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables) using documented and approved methods, standards, or handbooks. When volume control is employed using passive engineered features (e.g., use of approved fixed-geometry containers), volume control is considered equivalent to geometry control in terms of hierarchical preference. When the possibility of neutron interaction with other fissile units exists, interaction control or neutron absorber control may be indicated in conjunction with volume control.

Volume control parameter limits are established and implemented as follows:

- When using volume control, geometric devices typically are used to restrict the volume of SNM, which limits the accumulation of SNM.
- Instrumentation used to determine volume is subject to QA controls.
- Volume is limited to a percentage of the minimum critical volume; conservative configurations are used (i.e., assuming spherical geometry, optimal concentration, and water reflection).

6.4.4.11 Heterogeneity Control

Heterogeneity control involves taking credit for the distribution of fissile material. Heterogeneity control is applied in conjunction with another control mode (e.g., mass control,

geometry control). Heterogeneity control is typically implemented through process variable control as well. Additionally, it may be important to control the lattice pitch (i.e., spacing) in a heterogeneous configuration, such as a fuel rod or for pellet fabrication.

Heterogeneity control parameter limits are established and implemented as follows:

- When process variables can affect heterogeneity, the SSCs or procedures that affect process variables and potential mechanisms affecting homogeneity or nonhomogeneity are evaluated.
- Computer calculations that take heterogeneity into account are appropriately validated.

6.4.4.12 Physicochemical Control

Control of physicochemical characteristics is applied to several MFFF process units where non-optimal solution chemistry or specific values for some parameters (e.g., pellet diameter) are used in the definition of the fissile media and are assumed in criticality design calculations. The physicochemical form of the fissile material is defined by:

- Its chemical composition
- The pellet diameter (if applicable)
- The rod characteristics (if applicable)
- The assembly characteristics (if applicable).

For the AP process, a conservative or realistic (based on process information) assumption concerning the chemical form of the fissile matter is made for each step of the process, taking into account not only the nominal conditions, but also possible process upsets (e.g., failure of a PuO_2 filter or unwanted soda introduction that may cause precipitates) defined based on the double contingency principle. The different chemical forms used in the criticality analyses are:

- PuO_2
- $Pu(NO_3)_4$
- $Pu(NO_3)_3$
- Plutonium oxalate.

In the MP process, no chemical transformations take place. As a consequence, the oxide form of the fissile medium (PuO_2 and/or UO_2) is assumed.

6.4.4.13 Process Variable Control

Process variable control involves taking credit for process conditions maintained within fissile systems, including bounding normal operational tolerances on process parameters and upset conditions. Process variables can involve the other noted control modes, as well as the physical and chemical forms of the fissile material. Process variable control inherently requires some reliance on active engineered features. SSCs or procedures that control the parameters necessary to ensure that the process variables relied on for criticality safety are identified as IROFS in NCSEs, and are subject to QA controls sufficient to ensure that the associated controlled

parameter safety limit is not exceeded. The use of management measures discussed in Chapter 15 are required to ensure double contingency compliance.

6.4.5 Margin of Subcriticality and Double Contingency Principle

To develop the USL for each of the AOAs, accepted industry codes such as SCALE code packages using an accepted cross-section library (e.g., CSAS26 (KENOVI) sequence and the 238 energy group cross-section library 238GROUPNDF5) are used. (Other computation code systems may be used if they are qualified in accordance with the MPQAP.)

6.4.5.1 Regulatory Requirements, Guidance, and Industry Standards

Title 10 CFR §70.61(d) requires that "under normal and credible abnormal conditions, nuclear processes are subcritical, including use of an approved margin of subcriticality for safety." To comply with this requirement, an industry-accepted standard practice is used (i.e., ANSI/ANS-8.1). Industry standards note that a validation report is developed that describes the development of the USL, including (1) demonstrating the adequacy of the margin of subcriticality for safety by assuring that the margin is relatively large compared to the uncertainty in the calculated value of k_{eff}, and (2) determining the AOAs and use of the code within the AOA, including justification for extending the AOA by using trends in the bias.

6.4.5.2 Calculational Method

The SCALE code package is the computational system used for MFFF criticality analyses. (Other computation code systems may be used if they meet the requirements of the MPQAP.) This code package is available from the Radiation Safety Information Computational Center.

SCALE is a collection of modules designed to perform nuclear criticality, shielding, and thermal calculations. Each SCALE functional module may be run individually, or a sequence of functional modules may be executed using a special module referred to as a control module. For criticality analyses, various criticality safety analysis sequence (CSAS) control modules are available. The CSAS control modules differ in the specific functional modules executed and in the processing of cross sections used as input. As a practice, MFFF criticality analyses are performed using approved and industry-accepted control module and cross-section libraries. The calculation of k_{eff} is performed using the KENO VI Monte Carlo transport code.

6.4.5.3 Criticality Code Validation Methodology

To establish that a system or process is subcritical under normal and credible abnormal conditions, it is necessary to establish acceptable subcritical limits for the operation, and then show that the proposed operation will not exceed such subcritical limit. Software, meeting the requirements of the MPQAP, is used to determine the USL for each of the AOAs. Each documented, reviewed, and approved methodology validation report is incorporated into the configuration management program.

The criticality code validation methodology is divided into four steps:

- Identify general MFFF design applications. The MFFF design applications and key parameters are associated with normal and design abnormal conditions.
- Select applicable benchmark experiments and group them into AOAs.
- Model the criticality experiments and calculate k_{eff} values of selected critical benchmark experiments.
- Perform statistical analysis of results to determine computational bias and the USL.

There are several substeps associated with selecting and grouping benchmark experiments. First, based on the key parameters, the AOA and expected range of the key parameter are identified. ANSI/ANS-8.1-1983 defines the AOA as "The range of material composition and geometric arrangements within which the bias of a calculational method is established." AOAs covering plutonium (Pu) and MOX applications are as follows: (1) Pu-nitrate solutions; (2) MOX pellets, fuel rods, and fuel assemblies; (3) PuO_2 powders; (4) MOX powders; and (5) aqueous solutions of Pu compounds. After identifying the AOAs, a set of critical benchmark experiments is selected. Benchmark experiments for the AOAs are selected from industry-accepted data.

6.4.5.4 Determination of Bias

ANSI/ANS-8.1-1983, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors* requires a determination of the calculational bias by "correlating the results of critical and exponential experiments with results obtained for these same systems by the calculational method being validated." The correlation must be sufficient to determine if major changes in the bias can occur over the range of variables in the operation being analyzed. The standard permits the use of trends in the bias to justify extension of the area of applicability of the method outside the range of experimental conditions.

The recommended approach for establishing subcriticality based on numerical calculations of the neutron multiplication factor is prescribed in Section 5.1 of ANSI/ANS-8.17-1984, *Criticality Safety Criteria for the Handling, Storage, and Transportation of Light Water Reactor (LWR) Fuel Outside Reactors*. The criteria to establish subcriticality requires that for a design application (system) to be considered subcritical, the calculated multiplication factor for the system, k_s, is noted to be less than or equal to an established maximum allowed multiplication factor, based on benchmark calculations and uncertainty terms. That is:

$$k_s \leq k_c - \Delta k_s - \Delta k_c - \Delta k_m \qquad \text{(Eq. 6.4.5.4-1)}$$

where:

- k_s = the calculated allowable maximum multiplication factor, (k_{eff}) of the design application (system)
- k_c = the mean k_{eff} value resulting from the calculation of benchmark critical experiments using a specific calculation method and data
- Δk_s = the uncertainty in the value of k_s
- Δk_c = the uncertainty in the value of k_c
- Δk_m = the administrative margin.

Sources of uncertainty that determine Δk_s include:

- Statistical and/or convergence uncertainties
- Material and fabrication tolerances
- Limitations in the geometric and/or material representations used.

Sources of uncertainty that determine Δk_c include:

- Uncertainties in critical experiments
- Statistical and/or convergence uncertainties in the computation
- Extrapolation outside the range of experimental data
- Limitations in the geometric and/or material representations used.

Subcriticality requires the determination of an acceptable margin, based on known biases and uncertainties. The USL is defined as the upper bound for an acceptable calculation, as follows:

$$k_s + \Delta k_s \leq USL \qquad \text{(Eq. 6.4.5.4-2)}$$

The USL takes into account bias, uncertainties, and administrative and/or statistical margins, such that the calculated configuration is subcritical with a high degree of confidence.

6.4.5.5 Summary of USL for Each AOA

The development of the USLs takes into account bias and uncertainties, as well as an administrative margin. See Section 6.4.3 for a discussion of the administrative margin used for MFFF design applications within the AOAs. The USLs are applied as the basis for each nuclear criticality evaluation performed for MFFF. Table 6.4-1 identifies the USL, the key parameters and a definition of the MFFF AOAs.

6.4.6 Implementation of NCS in the ISA

Nuclear criticality calculations are performed for potentially fissile-bearing systems. In the design process, criticality safety calculations are performed to specify requirements for the design concept. The NCSEs assess both normal operating and process upset conditions. Where practical, nuclear criticality is precluded by demonstrating that the design is subcritical without the need to implement controls. In those cases in which it is not possible to demonstrate that a criticality is not credible, criticality control parameters are selected and limits on these parameters are established. Using the results of validated calculational methodologies, NCSEs demonstrate that both normal and process upset conditions meet the required minimum margin of subcriticality, and IROFS are identified to provide double contingency protection.

The NCSE evaluates normal and credible abnormal conditions developed in the component/ system Process Hazards Analysis (PrHA). The NCSEs demonstrate compliance with the double contingency principle. Passive engineered, active engineered, and administrative criticality safety controls relied on to meet double contingency ensure that a criticality cannot occur under credible conditions. Controls are based on criticality calculations for conservative geometries (e.g., spheres, cylinders, and slabs, and supporting criticality safety calculations) that evaluate

normal and credible abnormal conditions. Nominal configurations are also used to define the margin of safety. The criticality calculations determine and identify the criticality control (e.g., favorable geometry, safe spacing, process variables, concentration, content, configuration) for the components or system being evaluated.

Criticality safety during design and operation is ensured for the MFFF. MFFF design and safety features are NCS calculations and NCSEs that are documented, controlled, and maintained by implementing the management measures described in Chapter 15.

6.5 REGULATORY GUIDANCE APPLICABILITY

Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Materials Facilities* endorses specific NCS standards drafted by Subcommittee ANS-8 (Fissionable Materials Outside Reactors) of the ANS Standards Committee for these purposes. The MFFF criticality design basis includes use of ANSI/ANS standards endorsed by Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Materials Facilities* as described in this chapter. MFFF operations comply with the guidance ("shall" statements) and implement the appropriate recommendations ("should" statements) of the applicable ANSI/ANS standards referenced below.

ANSI/ANS-8.1-1983 (R1988), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, is part of the design basis of MFFF processes, and fissile material handling and storage areas. The standard provides general guidance addressing administrative and technical practices, as well as single-parameter and multiparameter control limits for systems containing ^{233}U, ^{235}U, and ^{239}Pu. Of particular significance to the MFFF design, ANSI/ANS-8.1-1983 (R1988) provides guidance for performing NCS analysis methodology validation. ANSI/ANS-8.1 NCS practices are referenced in the NCSEs to support MFFF design and operational approach. MFFF processes and storage areas that contain plutonium, uranium, or plutonium-uranium mixtures are explicitly evaluated using validated NCS analysis methodology, in accordance with the technical practice guidance of ANSI/ANS-8.1. However, criticality safety may be demonstrated by reference to ANSI/ANS-8.1 single-parameter and multiparameter control limits, in lieu of analysis.

Clarifications are noted as follows:

- Section 4.2.2: MFFF process, material handling, or storage area designs incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality event is possible. For the purposes of demonstrating compliance with this requirement, "unlikely" is defined as events or event sequences that are not expected to occur during the facility lifetime, but are considered credible.
- Section 4.2.3: MFFF process design relies on engineered features where practical, rather than administrative controls.
- Section 4.3.2: In cases where an extension in the area(s) of applicability of a NCS analysis methodology is required, the method is supplemented by other calculational methods to provide estimate of bias in the extended area(s). As an alternative, the

extension in the area(s) of applicability may also be addressed through an increased margin of subcriticality.

ANSI/ANS-8.3-1997, *Criticality Accident Alarm System*, is part of the design basis of MFFF process and fissile material handling and storage areas. The standard provides general guidance for the design, testing, and maintenance of criticality accident alarm systems at facilities where a criticality event may lead to excessive exposure to radiation. The scope of guidance provided in ANSI/ANS-8.3-1997 is applicable to MFFF design and operation.

MFFF operations comply with the guidance ("shall" statements) and implement the recommendations ("should" statements) of ANSI/ANS-8.3-1997 (and the corresponding guidance in Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Materials Facilities*).

ANSI/ANS-8.5-1996, *Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material*, is not part of the design basis, nor are Raschig Rings used at the MFFF.

ANSI/ANS-8.6-1989, *Safety in Conducting Subcriticality Neutron-Multiplication Measurements In Situ*, is not part of the design basis of the MFFF.

ANSI/ANS-8.7-1975, *Guide for Nuclear Criticality Safety in the Storage of Fissile Materials*, is not part of the design basis of the MFFF at this time, but may be used if the need arises.

ANSI/ANS-8.9-1987, *Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials*, has been officially withdrawn by the ANS-8 working group, but continues to be available for reference. This standard is not referenced as a basis for design of the MFFF. Intersections of process components and piping containing aqueous solutions of fissile materials are evaluated using validated NCS analysis methodology, in accordance with ANSI/ANS-8.1-1983 (R1988).

ANSI/ANS-8.10-1983, *Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement.* MFFF NCSEs performed for each process unit or area demonstrate compliance with the double contingency principle, consistent with guidance provided in Section 4.2.2 of ANSI/ANS-8.1-1983 (R1988). Therefore, this standard is not part of the design basis of the MFFF.

ANSI/ANS-8.12-1987, *Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors*, may be reaffirmed or withdrawn in future action by the ANS-8 working group (reference ANS-8 meeting minutes, Albuquerque, New Mexico, March 30, 2000). This standard is not part of the design basis of the MFFF at this time, but may be used if the need arises.

ANSI/ANS-8.15-1981, *Nuclear Criticality Control of Special Actinide Elements*, is not part of the MFFF criticality design basis, as it is applicable to operations with isolated units containing special actinide nuclides other than ^{233}U, ^{235}U, and ^{239}Pu. Nuclear criticality control of special

actinide nuclides is evaluated using validated NCS analysis methodology, in accordance with ANSI/ANS-8.1-1983 (R1988).

ANSI/ANS-8.17-1984, *Criticality Safety Criteria for the Handling, Storage, and Transportation of Light Water Reactor (LWR) Fuel Outside Reactors,* is part of the design basis of MFFF fissile material handling and storage areas. The standard provides guidance addressing general safety criteria and criteria for establishing subcriticality for handling, storage, and transportation of LWR fuel rods outside reactor cores. Of particular significance to the MFFF design, ANSI/ANS-8.17-1984 provides general guidance for combining the various biases, uncertainty, and administrative safety margin terms that are considered when performing criticality calculations to establish a final k_{eff} acceptance criterion.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.17-1984. Clarifications are noted as follows:

- Section 4.11: Fuel units and rods are handled, stored, and transported in a manner that provides a sufficient factor of safety to require at least two unlikely, independent, and concurrent changes in conditions before a criticality event is possible. This commitment is considered applicable to process, material handling, or storage area designs where a criticality event has been determined to be credible.
- Section 5.1: The criticality experiments used as benchmarks in computing k_c have physical compositions, configurations, and nuclear characteristics (including reflectors) similar to those of the system being evaluated.

ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety,* is part of the design basis of MFFF processes, and fissile material handling and storage areas. This standard provides criteria for the administration of a NCS program for operations outside reactors, for which there exists a potential for criticality events. An exception is noted as follows:

- Section 10: Guidance for planned response to nuclear criticality events are addressed by ANSI/ANS-8.23-1997. Therefore, no commitment is made to satisfy the guidance or recommendations of this section.

ANSI/ANS-8.20-1991, *Nuclear Criticality Safety Training*, is part of the design basis for MFFF operational practices. The standard provides detailed guidance for NCS training for personnel associated with (non-reactor) operations where a potential exists for criticality events.

MFFF operations will comply with the guidance ("shall" statements) and implement the recommendations ("should" statements) of ANSI/ANS-8.20-1991. No exceptions or clarifications are noted.

ANSI/ANS-8.21-1995, *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors,* is part of the MFFF design basis. The standard provides detailed guidance for use of fixed neutron absorbers in criticality control.

The MFFF will comply with the guidance of this standard ("shall" statements) and recommendations ("should" statements) to assure fixed neutron absorber material integrity and reliability to perform NCS functions. The guidance includes no recommendations that require further clarification and no exceptions are taken.

ANSI/ANS-8.22-1997, *Nuclear Criticality Safety Based on Limiting and Controlling Moderators,* is part of the MFFF design basis. The standard provides detailed guidance for limiting and controlling moderators to achieve criticality control.

- MFFF operations comply with the guidance ("shall" statements) and implement the recommendations ("should" statements) of ANSI/ANS-8.22-1997. This standard will be used as a guide and sections of it will be implemented as needed. An exception is noted as follows: Section 4.1.7: The design of MFFF fissile material storage areas has been reviewed, and administrative controls limiting the introduction of combustible materials during operation applied to ensure that an acceptable combustible loading is maintained. Fire protection provisions (i.e., fire suppression) in areas where fissile material is processed, handled, or stored are documented and justified.

ANSI/ANS-8.23-1997, *Nuclear Criticality Accident Emergency Planning and Response,* is part of the MFFF design basis (although not part of the criticality safety basis). The standard provides guidance for onsite emergency planning and response to nuclear criticality accidents.

The MFFF will comply with the guidance of this standard ("shall" statements) and recommendations ("should" statements) for guidance for onsite emergency planning and response to nuclear criticality accidents. The guidance includes no recommendations that require further clarification, and as discussed in Chapter 14, an Emergency Plan is not required to be submitted.

Tables

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Table 6.4-1. MOX MFFF Area of Applicability (AOA) and Upper Safety Limit (USL)

Area of Applicability (AOA)	AOA Key Parameters and Definition	Upper Safety Limit (USL) or Maximum K_{eff}
AOA (1)	Plutonium Nitrate Solutions • Geometry – Cylinder, slab, annular cylinders & arrays of cylinders • Reflectors – Full water, cadmium/water, & borated concrete • Chemical Form – Plutonium nitrate solution • Pu/(U + Pu) – 100 wt% • ^{240}Pu – 4 wt% • H/Pu – 100 – 200 • gPu/l – 125 – 237 • EALF – 0.14 – 0.25 eV	0.9370
AOA (2)	MOX Pellets, Fuel Rods and Fuel Assemblies • Geometry – Heterogeneous, rectangular lattices • Reflectors – Water • Chemical Form – MOX fuel • Pu/(U + Pu) – 6.3 wt% • ^{240}Pu – 4 wt% • v^f/v^m – 1.9 - 10 • EALF – 0.1 – 0.66 eV	0.9321
AOA (3)	Plutonium Oxide Powder • Geometry – Parallelepipeds, arrays of cylinders, spheres • Reflectors – Water • Chemical Form – PuO_2 powder • Pu/(U + Pu) – 100 wt% • ^{240}Pu – 4 wt% • H/Pu – 0 - 15 • EALF – 5.0 eV – 266 keV	0.9345
AOA (4)	Mixed Oxide Powder • Geometry – Parallelepipeds, spheres • Reflectors – Water, depleted uranium up to a reflector of 60 cm thickness • Chemical Form – MOX powder • Pu/(U + Pu) – 8 – 22 wt% • ^{240}Pu – 4 wt% • H/(U + Pu) – 2.8 - 15 • EALF – 0.63 – 92.6 eV	0.9249 * * 0.9349 + an additional nonparametric margin (NPM) of 0.01
AOA (5)	Solutions of Plutonium Compounds • Geometry – Parallelepipeds, arrays of cylinders, spheres • Reflectors – Water, cadmium, & borated concrete • Chemical Form – PuO_2F_2 solution • Pu/(U + Pu) – 100 wt% • ^{240}Pu – 4 wt% • H/Pu – 30 – 50, 85 - 210 • EALF – 0.685 – 4900 eV, 0.135 - 0.551 eV	0.9328

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7. FIRE PROTECTION

The Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) fire protection program establishes policies and institutes a program to promote life safety, the conservation of property, and the continuity of operations through provisions of fire prevention and fire protection measures. The program establishes defense-in-depth practices for the protection of items relied on for safety (IROFS) and the procedures, equipment, and personnel required to implement the program. The fire protection program extends the concept of multiple layers of defense in fire protection to:

- Prevent fires from starting
- Detect fires rapidly and determine their location
- Inform MFFF workers of fires
- Inform the Savannah River Site (SRS) Operations Center of fires
- Control and limit the spread of fires
- Promptly extinguish fires
- Maintain safe egress paths for plant personnel in the event of fire
- Protect IROFS when a fire is not promptly extinguished by the fire suppression systems, so that neither an uncontrolled release of radioactive materials nor a criticality event occurs.

MFFF conduct of operations, administrative controls, and fire protection features and systems provide protection against fires and explosions based on defense-in-depth practices described in this chapter.

7.1 ORGANIZATION AND CONDUCT OF OPERATIONS

Organizational responsibilities, lines of communication, and personnel qualification requirements are defined in the fire protection program. Program documentation includes an organization chart and functional descriptions of the responsibilities of fire protection program personnel. MFFF key management functions are described in Chapter 4. Specific management responsibilities for fire protection are described below.

The manager of the plant has overall responsibility for formulation, implementation, effectiveness, and assessment of the MFFF fire protection program. This position is responsible for the development and administration of MFFF operations and fire response plans, and the fire protection and prevention program including post-fire safety considerations. The manager of the plant is the single point of control and contact for fire contingencies.

The manager of the production function is responsible for implementing periodic inspections to minimize the amount of combustibles in areas with IROFS, and for determining the effectiveness of housekeeping practices. This position is responsible for assuring the availability and acceptable condition of fire protection systems and equipment, fire stops, and fire-rated penetration seals; and for assuring that prompt and effective corrective actions are taken to remedy conditions adverse to fire protection, and to preclude their recurrence.

The manager of the maintenance function is responsible for periodic inspection and testing fire protection systems and equipment in accordance with established procedures, which include evaluation of test results and determination of the acceptability of the system under test. This position ensures that personnel responsible for the maintenance and testing of the fire protection systems are qualified by training or experience for such work.

The manager of the quality assurance function is responsible for assuring the effective implementation of the quality-affecting aspects of the fire protection program by planned inspections and scheduled audits, identifying adverse conditions or trends, and reporting adverse conditions or trends to management.

The manager of the regulatory function is responsible for fire safety. The fire protection function reports to the manager of the regulatory function. The fire protection function has implementation responsibility for the overall fire protection program and has input to organizations involved in fire protection activities. The individual responsible for the fire protection function has at least five years of experience as a fire protection engineer. This position is responsible for reviews and evaluations of proposed work activities to identify potential transient fire loads. He periodically assesses the effectiveness of the fire protection program, including fire drills and training. The results of these assessments are reported to management, with recommendations for improvements or corrective actions, as deemed necessary. Fire fighting training is implemented by the fire protection function, consistent with the requirements of the MFFF training program. The fire protection function ensures that the content of fire protection training is current and adequate, by reviewing the training content on a regularly scheduled basis.

The manager of the training function is responsible for providing MFFF specific training to the SRS fire department (FD). This position assists in the critique of fire drills to determine how well the training objectives have been met. He is also responsible for implementing a program for indoctrination of MFFF personnel (including contractor personnel) in administrative procedures that implement the fire protection program and emergency procedures relative to fire protection, including handling of leaks or spills of flammable materials that may be related to fire protection.

The SRS FD is responsible for fighting fires at the MFFF. Coordination with the SRS FD and responsibilities of the SRS FD are defined in work-task agreements or procedures between the MFFF and SRS.

The Authority Having Jurisdiction for licensed activities is the U.S. Nuclear Regulatory Commission.

7.2 ADMINISTRATIVE CONTROLS

7.2.1 Fire Prevention

A key element of fire protection is fire prevention. The goal of fire prevention is to prevent a fire from starting. The basic components of fire prevention are:

- Prevention of fires and fire spread by placing controls on operational activities
- Design features such as the use of spark resistant electrical components where appropriate
- Design and administrative controls that restrict the use of combustible materials.

7.2.2 Surveillance Procedures

Fire protection surveillance procedures include inspections of combustible loading, fire protection equipment and systems, general housekeeping, and transient combustibles.

7.2.3 Control of Flammable and Combustible Materials

Flammable and combustible materials are controlled by design, and by procedures that limit:

- Bulk storage of combustible materials inside, or adjacent to, buildings or systems containing IROFS during operation or maintenance periods.
- Handling and use of ordinary combustible materials, combustible and flammable gases and liquids, combustible high efficiency particulate air and charcoal filters, dry ion exchange resins, pyrophoric materials, and other combustible supplies in areas containing IROFS. Flammable and combustible liquids are stored, handled, and used in accordance with applicable sections of National Fire Protection Association (NFPA) 30, *Flammable and Combustible Liquids Code*, 1996 edition.
- Storage and handling of pyrophoric metals to methods in the applicable codes and/or industry standards and require that an adequate supply of extinguishing agent for pyrophoric metals is present. Procedures for pyrophoric metals also establish operating limits and controls. Combustible loading in areas containing IROFS is in accordance with applicable guidance in NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 1998 edition. Flammable and combustible liquids are stored, handled, and used in accordance with applicable sections of NFPA 30, *Flammable and Combustible Liquids Code*, 1996 edition. Flammable and combustible gases are stored, handled, and used in accordance with applicable portions of NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1999 edition and NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, 1998 edition. Where appropriate, explosion prevention measures are implemented in accordance with applicable sections of NFPA 69, *Standard on Explosion Prevention Systems,* 1997 edition.
- Handling of transient fire loads, such as combustible and flammable liquids, wood and plastic products, or other combustible materials in buildings containing IROFS during the phases of operation, and especially during maintenance or modification activities.
- Use of wood is permitted only when noncombustible products are not practical from a process consideration. Where used, wood is treated with a flame retardant.
- Unpacking of transient combustible materials is done outside of MFFF production areas as much as practical. When necessary, transient combustible packing materials may be

unpacked inside MFFF production areas; however, the materials are removed from the area following unpacking. Loose combustible packing material — such as wood or paper excelsior or polyethylene sheeting — is placed in metal containers with tight-fitting, self-closing metal covers if the material remains in production areas.

- Work-generated combustible waste is removed from buildings containing IROFS following completion of the activity, or at the end of the shift, whichever comes first.

7.2.4 Control of Ignition Sources

Ignition sources are controlled by design such as selection of appropriate electrical equipment in gloveboxes where combustible material is present, absence of electrical equipment in process cells, and where appropriate, use of spark resistant electrical equipment. Ignition sources are also controlled by work control procedures requiring:

- Permits to control welding, grinding, flame cutting, brazing, or soldering operations; separate permits for each area where work is to be performed; and allowable duration for validity of permits
- Welding and grinding in accordance with applicable portions of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 1999 edition
- Prohibition of open flames or combustion-generated smoke for leak testing
- Smoking is restricted to designated areas outside of the MFFF buildings.

7.2.5 Testing, Inspection, and Maintenance

The MFFF fire protection systems and features are inspected, tested, and maintained. Inspection, testing, and maintenance are documented by means of written procedures, with the results and follow-up actions recorded. Water-based MFFF fire protection systems and equipment are inspected, tested, and maintained in accordance with applicable portions of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 1998 edition. Other MFFF fire protection systems are inspected, tested, and maintained in accordance with the applicable requirements of their applicable NFPA codes, manufacturer's guidelines, and operating experience. Safety controls and interlocks for combustible liquids, flammable liquids, and flammable gases and their associated delivery systems are tested periodically and after maintenance activities.

A test plan lists the responsible personnel positions in connection with routine tests and inspections of the fire detection and protection systems. The test plan contains the types, frequency, and identification of the testing procedures.

A penetration seal-tracking program records pertinent information regarding the installation and modification of fire-rated penetration seals that are IROFS.

Emergency lighting and communications systems are inspected, tested, and maintained in accordance with vendor recommendations.

Onsite and offsite emergency communications systems are tested periodically in accordance with the site emergency preparedness program.

7.2.6 Impairments

Fire protection is maintained during those periods when a fire protection system is impaired, or during periods of maintenance. To achieve this continuity of fire protection, written procedures address impairment of MFFF fire protection systems. Disarming of MFFF fire detection or fire suppression systems is controlled by a permit system. Together, the impairment procedure and permit system include the following:

- Identification and tracking of impaired equipment
- Identification of personnel to be notified
- Determination of needed compensatory fire protection and fire prevention measures.

If protection system impairment is planned, the necessary parts and personnel are assembled prior to removing the system from service. When an unplanned impairment occurs, or when a system has discharged, the repair work or fire protection system restoration is expedited.

Compensatory measures (e.g., fire watches) are implemented as appropriate in accordance with procedures when IROFS fire protection features and systems (i.e., Quality Level [QL]-1a fire barriers, fire doors, fire dampers, fire-rated penetration seals, fire suppression systems, and fire detection systems) are not operable.

Acceptable outage times are specified in work control procedures for fire protection system impairments. Exceeding the acceptable outage times for IROFS fire protection systems requires additional compensatory measures, which could include shutdown of processes in affected areas. Once repairs are completed, tests are conducted to ensure proper operation and restoration of fire protection equipment capabilities.

7.2.7 Fire Response Planning

Procedures identify actions to be taken by an individual discovering a fire, including guidance for notifying appropriate personnel. Procedures specify means and methods that may be used by MFFF staff to extinguish a fire (see also Section 7.4.2).

The response procedures specify actions to be taken to determine the need for assistance when a fire is reported or a fire alarm is received at an annunciation panel. For example, these actions may include announcing the location of a fire over the MFFF public address system, sounding fire alarms, notifying the shift supervisor, and notifying the SRS Operations Center.

7.2.8 Pre-fire Plans

Pre-fire plans are developed by the SRS Fire Department. They define the strategies that are used at MFFF for fighting fires in areas containing IROFS or that present a hazard to IROFS. For those areas, pre-fire plans identify:

- Fire hazards in each area covered by the specific pre-fire plans

- Fire extinguishing agents best suited for controlling the fires associated with the fire hazards in that area and the nearest location of these extinguishing agents
- The direction from which to attack a fire in each area in view of the ventilation direction, access hallways, stairs, and doors that are likely to be free of fire, and best station or elevation for fighting the fire. The access routes that involve locked doors are specifically identified with the appropriate precautions and methods for access specified
- Management of MFFF systems to reduce the damage potential during a fire and the location of local and remote controls for such management
- Heat-sensitive system components or hazardous combustibles that need to be kept cool while fighting a fire
- Coordination between MFFF staff and the SRS fire department
- Potential radiological and toxic hazards
- Operations requiring control room coordination or authorization
- Instructions for MFFF operators and general MFFF personnel during a fire.

7.3 FIRE PROTECTION FEATURES AND SYSTEMS

Fire protection features and systems consist of fire barriers, fire detection and alarm systems, fire suppression systems, fire protection water supply system, and smoke control features.

Fire protection features and systems, and implementation of industry codes and standards for fire protection, are described in the fire protection program. IROFS fire protection features and systems are described in the integrated safety analysis. Laboratories that use chemicals or nuclear materials are operated in accordance with applicable safety criteria of NFPA 45, *Standard for Fire Protection for Laboratories Using Chemicals*, 1996 edition.

Noncombustible storage racks within the MFFF are used for the storage of plutonium oxide, uranium oxide, or mixed oxide in powder, pellet, or rod form. Additionally, the areas where these storage racks are located are free of combustible material storage.

7.3.1 Fire Barriers

Fire barriers consist of walls, doors, windows, floors, ceilings, hatches, fire-rated penetration seals, and ventilation dampers. Fire barriers are used to separate IROFS and to separate areas that contain materials and processes that contain fire hazards into fire areas. Firewalls, floors, and ceilings are constructed of noncombustible materials. Firewalls maintain sufficient structural stability under fire conditions to allow the collapse of structures on either side without collapse of the wall itself. Structural members that support firewalls, floors, and ceilings have a fire-resistance rating that is equal to or greater than the barrier supported.

7.3.2 Fire Detection and Alarm Systems

Automatic fire detection systems actuate fire-extinguishing systems, fire/smoke dampers, and/or fire barrier devices. These systems alarm both locally with audible and visual alarms, and on an

MFFF central fire alarm panel in the Polishing and Utilities Control Room, and an alarm signal is transmitted to the SRS Operations Center. The SRS Operations Center Duty Officer dispatches SRS emergency responders. The MFFF central fire alarm panel identifies the location of the condition causing the alarm. Distinct alarms are provided for fire alarms, supervisory alarms, and system trouble alarms (alarm and supervisory system faults). Supervisory indications are provided for fire protection system status such as valve positions.

7.3.3 Fire Suppression Systems

Fire suppression systems provide fire suppression in the form of the appropriate extinguishing agent throughout the MFFF areas. A combination of fixed suppression systems, exterior hydrants, and portable fire extinguishers are used to provide fire suppression at the MFFF. Fire suppression systems for the MFFF are composed of the following:

- Water-based suppression systems provide fire suppression in areas where water is the preferred means of suppression. Due to nuclear criticality safety concerns, water is not used as a suppression agent in process rooms and in areas that contain nuclear material. Dry standpipe (preaction) systems are used in the aqueous polishing, MOX processing, and Shipping and Receiving areas. Wet-pipe sprinkler systems are used in buildings and areas that would not be significantly impacted by water damage from inadvertent operation of the sprinklers (for example, the Administration, Technical Support, Secured Warehouse, and Reagent Processing buildings).
- Carbon dioxide systems (portable CO_2 bottles) provide for manual fire suppression of incipient fires in gloveboxes. A specially configured portable CO_2 bottle can be manually connected to a glovebox and the CO_2 bottle actuated to extinguish incipient fires within gloveboxes.
- Clean agent systems provide fire suppression in areas where water-based suppression is undesirable, such as process rooms that contain nuclear material.
- Standpipe systems provide fire fighting water for manual fire suppression capabilities.
- Portable fire extinguishers are provided throughout the facility to provide for extinguishing fires during their incipient phase.

7.3.4 Fire Protection Water Supply System

The fire protection water supply system, which is primarily an underground firewater loop around the site, provides fire protection water to water-based fire protection systems. Potentially contaminated firewater is collected in contaminated drain systems.

7.3.5 Smoke Control Features

Smoke control features prevent the spread of smoke and combustion gases during a fire and remove smoke and combustion gases after a fire has been extinguished. The heating, ventilation, and air conditioning system uses filters and fire dampers to control smoke and combustion gases during and following a fire.

7.4 MANUAL FIRE FIGHTING CAPABILITY

The MFFF manual fire fighting capability consists of the SRS FD. The SRS FD is a full time professional fire department sufficiently trained and qualified to fight MFFF fires. Manual fire fighting needs assessments conducted by the SRS FD and Duke Cogema Stone & Webster (DCS) determined that minimum required onsite fire fighting capabilities are met by the SRS FD.

7.4.1 Equipment

Fire fighting equipment, including portable fire extinguishers, is maintained and inspected based on experience, manufacturer's recommendations, and applicable codes to assure the safe operational condition of the equipment.

7.4.2 Training

The SRS FD is provided training in operational precautions, radiological protection, and special hazards that could be present when fighting fires on the MFFF site. General employee training provides MFFF employees with training on actions to take upon discovering a fire, including notifications, when it is appropriate to attempt to extinguish a fire, and fire fighting methods that may be used, including manual activation of suppression systems.

7.4.3 Fire Drills

Fire drills are performed at regular intervals in the MFFF with the SRS FD.

7.5 FIRE HAZARDS ANALYSIS

MFFF's fire hazards analysis is reviewed and updated periodically at defined intervals and as necessary following changes and modifications to the facility, processes, or inventories in accordance with DCS's configuration management process (Chapter 15).

8. CHEMICAL SAFETY

Chemical safety for the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) has two main aspects. The first aspect of chemical safety is control of the chemical hazards that apply to the chemicals that do not interact with licensed materials and do not impact the safety of licensed materials. For this set of chemical hazards, which is not regulated by the U.S. Nuclear Regulatory Commission (NRC), and hence outside the scope of this license application, Duke Cogema Stone & Webster (DCS) has established and maintains a safety program that includes protection against industrial chemical hazards. The second aspect of chemical safety for the MFFF is control of chemical hazards of licensed material, hazardous chemicals produced from licensed material, and plant conditions impacting the safety of licensed material (resulting in an increased radiological risk).

This chapter describes the chemical hazard identification process, process chemistry and potential interactions, chemical hazards analysis methodology, and chemical process safety interfaces with programmatic areas and management measures.

The integrated safety analysis (ISA) includes identification and evaluation of chemical hazards that may impact radiological safety and chemical hazards directly associated with NRC-licensed radioactive material. The ISA process includes designation of items relied on for safety (IROFS) to provide adequate protection against chemical risks from licensed material, facility conditions that affect the safety of licensed material, and hazardous chemicals produced from licensed material. The ISA identifies the controls—both engineered and administrative IROFS—that are used either to prevent the occurrence of chemical-related accidents, or to mitigate the consequences of potential accidents to acceptable levels. DCS maintains continuity of control over IROFS during design, construction, and operations by implementing the MFFF configuration management processes. This control extends to chemical safety, which is an integral component of the ISA process. Chapter 5 describes DCS programmatic commitments for the conduct and maintenance of the ISA, and summarizes the ISA methodology, including chemical safety aspects.

An overview of the MFFF processes is provided in Chapter 1. Descriptions of the chemical processes, hazardous chemicals, potential accident sequences, and controls are provided in the ISA.

8.1 CHEMICAL INFORMATION

A wide variety of chemical products, several of which are hazardous, are used in the Aqueous Polishing (AP) and MOX Process (MP) processes at the MFFF. Table 8.1-1 lists the hazardous characteristics and incompatibilities associated with these chemicals. Of the chemicals used in the AP and MP processes, at least 17 exhibit one of the following hazardous characteristics:

- Corrosivity
- Flammability
- Explosivity
- Chemical burn
- Toxicity.

Tables 8.1-2 through 8.1-5 list the process chemicals used at the MFFF by location, with chemical formula, chemical state, and Central Abstract System Registry Number (CASRN). In addition, two chemicals (uranium dioxide and uranyl nitrate) that are stored in the Secured Warehouse Building (BSW) are listed in Table 8.1-6.

Numerous reagents are used in the AP process, with a summary description of these reagent systems provided in Section 11.6.3. These reagent systems are designed such that segregation/separation of vessels/components from incompatible chemicals is assured to prevent chemical explosions under normal, off-normal, and accident conditions including earthquakes. Rigid control of the chemical makeup of the reagents introduced into the cells or AP reagent rooms prevents explosions caused by chemical reactions. Chemicals, piping, tanks, and other components in the Nitric Acid (RNA) system are clearly labeled to prevent reagent preparation errors. Safety precautions are used in handling reagents, in accordance with Material Safety Data Sheet requirements.

The following reagents support the AP process functions:

- Nitric Acid
- Tributyl Phosphate
- Hydroxylamine Nitrate
- Sodium Hydroxide
- Oxalic Acid
- Diluent
- Sodium Carbonate
- Hydrogen Peroxide
- Hydrazine
- Manganese Nitrate
- Aluminum Nitrate
- Zirconium Nitrate
- Silver Nitrate
- Sodium Sulfite
- Sodium Nitrate
- Uranyl Nitrate.

Table 8.1-7 provides a list of these reagents (some listed more than once if used in differing concentrations), along with the downstream transfer unit, and the normal operating range.

In addition, the following reagents will be used in either the MP process or as oxygen scavengers in the steam and condensate system:

- Zinc stearate
- Azodicarbonamide
- Carbohydrazide
- Morpholine borane.

Zinc stearate is a lubricant used in the MP process. It is packed in small ready-to-use plastic bags that are manually introduced into the relevant powder process glovebox to be mixed with powders in process. The bags are introduced into the gloveboxes via a glove port using a "bag-in bag-out" procedure.

Azodicarbonamide is a poreformer used in the MP process. It is also packed in small ready-to-use plastic bags that are manually introduced into the relevant powder process glovebox to be mixed with powders in process. The bags are introduced into the gloveboxes via a glove port using a "bag-in bag-out" procedure.

Carbohydrazide and Morpholine Borane are used as oxygen scavengers in the steam and condensate (SPS) system (see Section 11.6.1). Carbohydrazide will be purchased as a solid, while morpholine borane will be delivered as a liquid.

8.2 CHEMICAL PROCESS INFORMATION

This section discusses the evaluation of potential chemical interactions to identify those chemicals that cannot be mixed, and those mixtures that could create a safety hazard (e.g., a fire or explosion). Potential adverse reactions between the reagents used in the AP process are examined. In addition, interactions between the reagents and actinides of plutonium and uranium are examined to identify possible hazards related to colloids formation, polymerization of plutonium, precipitate formation, or explosion. Furthermore, interaction between the reagents and water is assessed. Finally, interactions between the reagents used in the AP process and those used in the MP process or as oxygen scavengers, is investigated for possible hazards.

The chemical processes that take place as a part of normal operations at the MFFF are described briefly in Section 1.1.7 of this License Application, with further descriptions and evaluations provided as a part of the ISA.

A complete chemical interaction matrix for the AP reagents has been generated to evaluate possible chemical interactions and the appropriate controls required on process parameters to ensure that hazardous interactions are prevented or mitigated. These chemicals are postulated to be mixed either by failure of operations or equipment within the AP process itself, or an inadvertent mixing by a technician in the Reagents Processing Building or MOX Processing Area laboratories.

A detailed evaluation of the chemical interactions that must be prevented is provided in the ISA. The ISA includes an analysis of the potential for explosions and the IROFS that are required to prevent these events. In addition, events involving chemical releases, alone or in combination with radioactive releases, are evaluated. IROFS are identified to protect against these chemical risks at the MFFF.

8.3 CHEMICAL HAZARDS ANALYSIS

8.3.1 Consequence Analysis Methodology

As a part of the hazard assessment process performed as a part of the ISA, potential accident events are identified and evaluated that could result in acute chemical exposure from licensed

material or hazardous chemicals produced from licensed material. The baseline design criteria require (Title 10 of the Code of Federal Regulations (CFR) §70.64(a)(5)) that the design provide for adequate protection against chemical risks produced from licensed material, facility conditions that affect the safety of licensed material, and hazardous chemicals produced from licensed material. This section describes the methodology for the evaluation of the chemical consequences associated with a release of hazardous chemicals.

8.3.1.1 Quantitative Standards for Chemical Consequences Levels

Chemical concentration limits are required to be established to evaluate the potential consequences to the individual outside of the controlled area (IOC) and to workers for an accidental release of chemicals. Three levels, High (H), Intermediate (I), and Low (L), based on 10 CFR §70.61, are used to define these limits.

A high consequence event is one that results in any of the following:

- An intake of 30 mg or greater of uranium in soluble form by an individual located outside the controlled area;
- An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that could endanger the life of a worker;
- An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that could lead to irreversible or other serious, long-lasting health effects to an individual located outside the controlled area.

An intermediate consequence event is one that results in any of the following:

- An acute chemical exposure to an individual to licensed material or hazardous chemicals produced from licensed material that could lead to irreversible or other serious, long-lasting health effects to a worker;
- An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that could cause mild transient health effects to an individual located outside the controlled area.

Quantitative standards are required to correctly categorize exposures per the qualitative criteria established in 10 CFR §70.61. Limits are based on Acute Exposure Guideline Level (AEGL) values and Emergency Response Planning Guideline (ERPG) values. However, since AEGL and ERPG values are not established for MFFF chemicals, Temporary Emergency Exposure Limits (TEELs) have been adopted for use in chemical consequence analysis for those chemicals where AEGL or ERPG values have not been established. TEELs were adopted by the DOE Subcommittee on Consequence Assessment and Protective Action (SCAPA). The SCAPA-approved methodology was used to obtain hierarchy-derived TEELs.

The original TEEL methodology used only hierarchies of published concentration limits (that is, Permissible Exposure Levels [PELs] or Threshold Limit Values – Time-Weighted Averages [TLV-TWAs], Short-Term Exposure Levels [STELs], and Immediately Dangerous to Life and Health [IDLH] values) to provide estimated values approximating ERPGs. The expanded

method for deriving TEELs also includes published toxicity data (Toxic Dose Low $[TD]_{LO}$, Toxic Concentration Low $[TC]_{LO}$, 50% Lethal Dose $[LD]_{50}$, 50% Lethal Concentration $[LC]_{50}$, Lethal Dose Low $[LD]_{LO}$, and Lethal Concentration Low $[LC]_{LO}$). Hierarchy-based values take precedence over toxicity-based values, and human toxicity data are preferred to animal toxicity data. Subsequently, default assumptions based on statistical correlation of ERPGs at different levels (for example, ratios of ERPG-3s to ERPG-2s) were used to calculate TEELs where there were gaps in the data. The TEEL hierarchy/toxicity methodology was used to develop community exposure limits for over 1,200 chemicals to date. The following are the TEEL definitions:

- TEEL-0 – The threshold concentration below which most people will experience no appreciable risk of health effects.
- TEEL-1 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
- TEEL-2 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- TEEL-3 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

The definitions of TEEL severity levels are consistent with 10 CFR §70.61. See Table 8.3-1 for a listing of the TEEL-1, -2, and -3 values for MFFF chemicals.

Events involving uranium are categorized based on the chemical consequences instead of radiological consequences. For uranium accidents, uptakes may be used instead of concentration-based TEELs to establish consequence categories. An event that results in an uptake of 30 mg uranium may be considered to lead to irreversible or other serious, long-lasting health effects to an individual. An uptake of 10 mg uranium may be considered to cause mild transient health effects (Hartmann, Heidi M., Frederick A. Monette, and Halil I. Avci, "Overview of Toxicity Data and Risk Assessment Methods for Evaluating the Chemical Effects of Depleted Uranium Compounds", *Human and Ecological Risk Assessment, Vol. 6, No. 5,* 2000). Hence, controls are applied to uranium events if the potential intake of uranium exceeds 10 mg to limit acute chemical exposure to an individual.

The chemical consequence categories used to define the level of risk are provided in Table 8.3-2.

8.3.1.2 Chemical Event Release Scenarios

The chemical consequences for the facility worker, site worker, and IOC are assessed for events identified in the hazard evaluation as part of the ISA. These events include releases from two locations in the MFFF: (1) the MFFF building stack, and (2) the Secured Warehouse Building (BSW). The facility worker is considered to be located inside a room near a potential accident

release point. The site worker is considered to be 100 m from the release point. Both facility workers and site workers are deemed to be "workers." The IOC is defined as the maximally exposed individual outside the controlled area boundary, either 68 m (for BSW releases) or 160 m (for MFFF building stack releases) from the release point.

8.3.1.3 Atmospheric Dispersion

Chemical releases are modeled as instantaneous releases to the facility worker and are conservatively modeled for the site worker and the IOC using a 0- to 2-hour 95th percentile atmospheric dispersion factor (χ/Q). The ARCON96 computer code is used to compute the downwind relative air concentrations (χ/Q) for the site located within 100 m of a ground-level release from the MFFF to account for low wind meander and building wake effects, and for the IOC located at either 68 m or 160 m from the release point. The 0- to 2-hour atmospheric dispersion factor (χ/Q) for ground-level releases to the site worker at 100 m is 6.1×10^{-4} sec/m^3. For the IOC, the 0- to 2-hour atmospheric dispersion factor (χ/Q) for ground-level releases is (1) 1.25×10^{-3} sec/m^3 at 68 m from the release point, and (2) 2.5×10^{-4} sec/m^3 at 160 m.

8.3.1.4 Chemical Consequences

In lieu of a mechanistic calculation of the release, a conservative bounding release model was used to determine the consequences to the site worker and IOC from releases either from the BSW, or the MFFF building stack, as applicable. Releases were modeled to occur using the total material at risk from the largest single tank or container. Furthermore, no credit was afforded to process equipment installed to remove/scrub some of the potentially released chemicals prior to release from the MFFF.

Estimates of hazardous chemical concentrations include techniques, assumptions, and models that are consistent with industry practice, were verified and/or validated, and follow the guidance on atmospheric and consequence modeling found in NUREG/CR-6410, *Nuclear Fuel Cycle Accident Analysis Handbook*.

Airborne concentrations were calculated at distances correlating to the site worker (100 m) and the IOC (either 68 m or 160 m). These concentrations were then compared to the chemical limits presented in Table 8.3-1. From this comparison, a consequence category was established (low, intermediate, high) using the guidance outlined in Table 8.3-2. These consequence categories correspond to those identified in 10 CFR §70.61.

8.4 ORGANIZATIONAL STRUCTURE

DCS key management functions with responsibilities for IROFS and related activities are described in Chapter 4. This includes IROFS established by the ISA to protect against chemical risks from licensed material, facility conditions that affect the safety of licensed material, and hazardous chemicals produced from licensed material. Responsibility for performing and maintaining the ISA is described in Chapter 5.

8.5 CHEMICAL PROCESS SAFETY INTERFACES

Aspects of MFFF chemical process safety have interfaces with the following programmatic areas and management measures:

- Human factors engineering
- Emergency management
- Quality assurance
- Configuration management
- Maintenance
- Training and qualification
- Plant procedures
- Audits and assessments
- Incident investigations
- Records management.

8.5.1 Interfaces with Programmatic Areas

DCS applies criteria for human factors engineering to the design of MFFF IROFS with associated personnel activities for operation or maintenance (i.e., the scope of human factors engineering is associated with IROFS, whose function is protection against radiological, chemical, and criticality hazards). The MFFF is a highly automated facility based in large part on the design and operating experience of existing facilities. The highly automated nature of the facility limits the number of personnel activities designated IROFS. The application of human factors engineering to MFFF IROFS is described in Chapter 12.

As described in Chapter 14, an emergency plan is not required to be submitted.

8.5.2 Interfaces with Management Measures

Management measures supplement MFFF IROFS by providing the administrative and programmatic framework for configuration management, maintenance, training and qualification, procedures, audits and assessments, incident investigation, and records management. The MOX Project QA Plan (MPQAP) and management measures are described in Chapter 15.

Personnel responsible for performing activities involving chemical safety are qualified and trained in accordance with the MFFF training and qualification program, specifically, applicable training for IROFS associated with chemical hazards. A general discussion of qualification and training of personnel is provided in Chapter 15.

Activities associated with IROFS are conducted in accordance with approved procedures. MFFF plant procedures govern operations, maintenance, and administrative actions to ensure that IROFS are operated in a manner consistent with the results of the ISA. Plant procedures associated with items relied on for chemical safety take into account chemical hazards, as well as radiological and criticality hazards, as appropriate for the activity. A general discussion of procedures is provided in Chapter 15.

Audits and assessments are used to determine the effectiveness of management measures, including those associated with chemical safety. Audit and assessment attributes (e.g., independence of auditors from personnel responsible for the chemical safety activities being audited, reports to management) are consistent with those for other MFFF IROFS. A general discussion of the audit and assessment program is provided in Chapter 15, with a more detailed description given in the MPQAP.

Incident investigation activities identify corrective actions for, and root causes of, incidents that involve MFFF IROFS, including those related to chemical safety. A general discussion of the incident investigation /corrective action implementation is provided in Chapter 15, with a more detailed description given in the MPQAP.

Chemical safety records are controlled in accordance with configuration management processes, the requirements of the MPQAP, and the records management program. Chemical safety records are processed and retained in the same manner as records associated with other IROFS and related programs, as described in Chapter 15.

Tables

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Table 8.1-1. Process Chemical Hazardous Characteristics and Incompatibilities

Chemical	Chemical Formula	Corrosivity	Flammability	Explosivity	Chemical Burn	Toxicity	Incompatibilities
Aluminum Nitrate Nonahydrate	$Al(NO_3)_3 \cdot 9H_2O$	x			x	x	Combustible materials, strong reducing agents, metals, water, strong acids
Argon	Ar						None
Diluent (Dodecane isomer mix)	$C_{12}H_{26}$ (mixture)		x	x		x	Oxidizing agent, oxygen
Dinitrogen Tetroxide	N_2O_4	x			x	x	Hydrocarbon, aluminum, chrome
Helium	He						None
Hydrazine Monohydrate	$N_2H_4 \cdot H_2O$	x	x	x	x	x	Oxidizing agent, metal, asbestos
Hydrogen	H_2		x	x			None
Hydrogen peroxide	H_2O_2		x	x	x	x	Organics, nitric acid, manganese
Hydroxyl Amine Nitrate (HAN)	NH_2OH HNO_3	x		x	x	x	Bichromate and permanganate of potassium, copper sulfate, zinc
Manganese Nitrate	$Mn(NO_3)_2$	x			x	x	Strong reducing agents, combustible materials
Methane-Argon Mixture (P10)	CH_4 (10%) - Ar (90%)						None
Nitric acid (13.6N)	HNO_3	x			x	x	Organics, hydrogen peroxide
Nitrogen Dioxide	NO_2					x	Hydrocarbon, aluminum, chrome
Oxalic Acid Dihydrate (also present as solid)	$H_2C_2O_4 \cdot 2H_2O$				x	x	Silver, sodium chloride, sodium hypochlorite reacts with sulfuric acid to form carbon monoxide, solid is hygroscopic
Oxygen	O_2		x			x	Organics
Pre-mixed Argon-Hydrogen	Ar (95%) – H_2 (5%)						None

Table 8.1-1. Process Chemical Hazardous Characteristics and Incompatibilities (continued)

Chemical	Chemical Formula	Corrosivity	Flammability	Explosivity	Chemical Burn	Toxicity	Incompatibilities
Silver Nitrate (also present as liquid)	$AgNO_3$	x			x	x	Ammonia, carbonates, chlorides, alcohols, magnesium, strong bases, strong reducing agents (Note: solid is air, moisture and light sensitive)
Sodium Carbonate	Na_2CO_3					x	None
Sodium Hydroxide	NaOH	x			x	x	Acid, aluminum, and other metals, organic halogens (especially trichloroethylene) and sugars
Sodium Nitrite	$NaNO_2$				x	x	Reducing agents, ammonium salts, sodium bisulfite, organics, combustible materials
Sodium Sulfite (also present as liquid)	Na_2SO_3				x	x	Strong oxidizers, acids, organics, combustible materials. (Note: solid is air and moisture sensitive)
Tri-Butyl Phosphate (TBP)	$(C_4H_9)_3PO_4$		x	x	x	x	Ammonia, oxidizing agent

Table 8.1-2. Process Chemicals in the Reagents Processing Building (BRP)

CHEMICAL			
Name	**Formula**	**CASRN**	**State**
Diluent (C10-C13 Isoalkanes)	$C_{12}H_{26}$ (mixture)	68551-17-7	Liquid
Hydrazine Monohydrate	$N_2H_4.H_2O$	7803-57-8	Liquid
Hydrazine Nitrate (Note 1)	N_2H_4-HNO_3	13464-97-6	Liquid
Hydrogen Peroxide	H_2O_2	7722-84-1	Liquid
Hydroxyl Amine Nitrate (HAN)	NH_2OH-HNO_3	13465-08-2	Liquid
Nitric Acid	HNO_3	7697-37-2	Liquid
Nitrogen Dioxide (Note 2)	NO_2	10102-44-0	Gas
Dinitrogen tetroxide	N_2O_4	10544-72-6	Liquid/Gas
Oxalic Acid	$H_2C_2O_4$	144-62-7	Solid/Liquid
Silver Nitrate	$AgNO_3$	7761-88-8	Solid/Liquid
Sodium Carbonate	Na_2CO_3	497-19-8	Solid/Liquid
Sodium Hydroxide	NaOH	1310-73-2	Liquid
Sodium Sulfite	Na_2SO_3	7757-83-7	Liquid
Tributyl Phosphate	$(C_4H_9)_3PO_4$	126-73-8	Liquid
Zirconium Nitrate	$Zr(NO_3)_2$*$5H_2O$	13746-89-9	Liquid

Notes:

1. Hydrazine nitrate is made up in the BRP from hydrazine monohydrate and nitric acid.
2. Nitrogen dioxide is the coexisting dimer of dinitrogen tetroxide in gas form.

Table 8.1-3. Process Chemicals in the Aqueous Polishing Building (BAP)

CHEMICAL			
Name	**Formula**	**CASRN**	**State**
Aluminum Nitrate	$Al(NO_3)_3*9H_2O$	13473-90-0	Liquid
Chlorine (Note 1)	Cl_2	7782-50-5	Gas
Diluent (C10-C13 Isoalkanes)	$C_{12}H_{26}$ (mixture)	68551-17-7	Liquid
Hydrazine (0.2 N)	N_2H_4	302-01-2	Liquid
Hydrazine Nitrate	N_2H_4-HNO_3	13464-97-6	Liquid
Hydrogen Peroxide	H_2O_2	7722-84-1	Liquid
Hydroxylamine Nitrate (HAN)	NH_2OH-HNO_3	13465-08-2	Liquid
Manganese Nitrate	$Mn(NO_3)_2$	10377-66-9	Solid/Liquid
Nitric Acid	HNO_3	7697-37-2	Liquid
Nitric Oxide (Note 1)	NO	10102-43-9	Gas
Nitrogen	N_2	7727-37-9	Gas
Nitrogen Dioxide	NO_2	10102-44-0	Gas
Nitrogen Oxides (Note 1)	NO_x	N/A	Gas
Oxalic Acid	$H_2C_2O_4$	144-62-7	Liquid
Oxygen	O_2	N/A	Gas
Plutonium Dioxide	PuO_2	N/A	Solid
Plutonium Oxalate (Note 2)	$Pu(C_2O_4)_2$	N/A	Solid/Liquid
Plutonium Nitrate (Note 2)	$Pu(NO_3)_4$	N/A	Liquid
Silver Nitrate	$AgNO_3$	7761-88-8	Solid/Liquid
Sodium Carbonate	Na_2CO_3	497-19-8	Liquid
Sodium Hydroxide	NaOH	1310-73-2	Liquid
Sodium Nitrite	$NaNO_3$	7632-00-0	Liquid
Sodium Sulfite	Na_2SO_3	7757-83-7	Liquid
Tributyl Phosphate	$(C_4H_9)_3PO_4$	126-73-8	Liquid
Uranyl Nitrate	$UO_2(NO_3)_2$	36478-76-9	Liquid
Zirconium Nitrate	$Zr(NO_3)_2*5H_2O$	13746-89-9	Liquid

Notes:

1. Chlorine and nitrogen oxides are by-products of AP processing.
2. Plutonium oxalate and plutonium nitrate are intermediate products of AP processing.

Table 8.1-4. Process Chemicals in the MOX Processing Building (BMP)

CHEMICAL			
Name	**Formula**	**CASRN**	**State**
Argon-Hydrogen	95% Ar; 5% H	N/A	Gas
Azodicarbonamide (poreformer)	$H_2NCONNCONH_2$	123-77-3	Solid
Helium	He	7440-59-7	Gas
Isopropanol	C_3H_7OH	67-63-0	Liquid
Nitrogen	N_2	7727-37-9	Gas
Plutonium Dioxide	PuO_2	N/A	Solid
Uranium Dioxide	UO_2	1344-57-6	Solid
Zinc Stearate	$Zn(C_{18}H_{35}O_2)_2$	557-05-1	Solid

Table 8.1-5. Process Chemicals in the Laboratories

CHEMICAL			
Name	**Formula**	**CASRN**	**State**
Aluminum Nitrate	$Al(NO_3)_3*9H_2O$	13473-90-0	Liquid
Acetic Acid	$C_2H_4O_2$	64-19-7	Liquid
Acetonitrile	C_2H_3N	75-05-8	Liquid
Ammonium bi-fluoride	F_2H_5N	1341-49-7	Liquid
Argon	Ar	N/A	Gas
Argon-Hydrogen	95% Ar; 5% H	N/A	Gas
Argon-Methane (P10)	90% Ar; 10% CH_4	N/A	Gas
Ascorbic Acid	$C_6H_8O_6$	50-81-7	Liquid
Chromic (III) Acid	CrO_3	7738-94-5	Liquid
Ethanol	C_2H_6O	64-17-5	Liquid
Ethylene Glycol	$C_2H_6O_2$	107-21-1	Liquid
Ferrous sulfate	$FeSO_4$	7720-78-7	Liquid
Helium	He	N/A	Gas
Hydrofluoric Acid	HF	7664-39-3	Liquid
Hydrogenated Propylene Tetramer (diluent)	$C_{12}H_{24}$	25378-22-7	Liquid
Hydroxyl Amine Nitrate	$NH_2OH\text{-}HNO_3$	13465-08-2	Liquid
Liquid Nitrogen	N_2	N/A	Liquid
Methanol	CH_4O	67-56-1	Liquid
Nitric Acid	HNO_3	7697-37-2	Liquid
Nitrogen	N_2	7727-37-9	Gas
Nitrogen/Helium (70%/30%)	N_2/He	N/A	Gas
Oxygen	O_2	N/A	Gas
Potassium Iodide	KI	7681-11-0	Liquid
Potassium Nitrate	KNO_3	7757-79-1	Liquid
Silver Nitrate	$AgNO_3$	7761-88-8	Liquid
Silver Oxide	AgO	20667-12-3	Liquid
Sodium Acetate	$AgHNO_3$	7761-88-8	Liquid
Sodium Carbonate	Na_2CO_3	497-19-8	Liquid
Sodium Hydrogen Sulfate	NaHSsub>4	7681-38-1	Liquid
Sodium Hydroxide	NaOH	1310-73-2	Liquid
Sodium Nitrate	$NaNO_3$	7631-99-4	Liquid
Sodium Nitrite	$NaNO_2$	7632-00-0	Liquid
Sodium Oxalate	$C_2Na_2O_4$	62-76-0	Liquid
Sulfamic Acid	HSO_3NH_2	5329-14-6	Liquid
Sulfuric Acid	H_2SO_4	7664-93-9	Liquid
Tetrahexyl Ammonium Bromide	$C_{24}H_{52}BrN$	12124-97-9	Liquid
Thenoyl Trifluoroacetone	$C_8H_5F_3O_2S$	326-91-0	Liquid
Tributyl Phosphate	$C_{12}H_{27}O_4P$	126-73-8	Liquid

Table 8.1-6. Chemicals in the Secured Warehouse Building (WSB)

CHEMICAL			
Name	**Formula**	**CASRN**	**State**
Uranium Dioxide	UO_2	1344-57-6	Solid
Uranyl Nitrate	$UO_2(NO_3)_2$	36478-76-9	Liquid

Table 8.1-7. Reagents used in the AP Process

Chemical Name	Reagent Formula	Downstream Transfer Unit of Concern	Normal Operating Range
RNA Nitric acid	13.6N HNO_3	KDB KDD KPA KCA KCD LGF	13.6N
RNA Nitric acid	6N HNO_3	KDD KDB KPA	6N
RNA Nitric acid	1.5N HNO_3	KDD KDB KPA	1.5N
RHN/RHZ Hydroxylamine nitrate /Hydrazine Mixture	$NH_2OH.HNO_3$ NH_2NH_2	KPA	1.85M 0.1M
RHN/RHZ Hydroxylamine nitrate /Hydrazine Mixture	$NH_2OH.HNO_3$ NH_2NH_2 HNO_3	KPA	0.15M 0.1M 1N<X<13.6N
RTP Tributyl Phosphate	$(C_4H_9)_3PO_4$	KPB	99%
RTP Tributyl Phosphate	$(C_4H_9)_3PO_4$	KPA via KPB	30%
RDO Diluent Hydrogenated polypropylene tetramer	HPT (C_{10}, C_{11}, C_{12}, C_{13}) Mixtures	KPA and KPB	70%
RHP Hydrogen Peroxide	10 wt% H_2O_2	KDB KDD	10 wt%
RSN Silver nitrate in nitric acid	1.5 M $AgNO_3$ in 3.0 N HNO_3	KDB KDD	1.5M
RSC Sodium Carbonate	Na_2CO_3	KPB	0.3M

Table 8.1-7. Reagents used in the AP Process (continued)

Chemical Name	Reagent Formula	Downstream Transfer Unit of Concern	Normal Operating Range
RSH Sodium Hydroxide	NaOH	KDD KWD RNA	10N
RSH Sodium Hydroxide	NaOH	KPB	0.1N
RSS Sodium Sulfite	Na_2SO_3	KDD	0.5M
ROA Oxalic Acid	$H_2C_2O_4$	KCA	0.7M
ROA Oxalic Acid	0.05M $H_2C_2O_4$ in 2.0N HNO_3	KCA	0.05M
RZN Zirconium nitrate	10 g/L $Zr(NO_3)_4.5H_2O$ in 3.5 N HNO_3	KPA KPC	10 g/L
RUN Uranyl Nitrate	$UO_2(NO_3)_2$ 200g U/L in 1.0N HNO_3	KPA KDB KDD	200g /L of U
RMN Manganese Nitrate in nitric acid	0.01M $Mn(NO_3)_2$ in 13.6N HNO_3	KCA	0.01M
RAN Aluminum Nitrate	$Al(NO_3)_3.9H_2O$ diluted in 1.5 N HNO_3	KPA	1g/L of Al
RSI Sodium Nitrite	$NaNO_2$	KWD (destruction of azide)	400 g/L

Table 8.3-1. TEELs (mg/m^3) Used as Chemical Limits for Chemicals at the MFFF (Note 1)

Name	TEEL-1	TEEL-2	TEEL-3
Acetic Acid	35	75	125
Acetonitrile	100	100	750
Aluminum Nitrate	15	15	500
Argon	350,000	500,000	750,000
Ascorbic Acid	200	500	500
Azodicarbonamide	125	500	500
Boric Acid	30	50	125
Dry cement (i.e., calcium carbonate)	15	15	15
Calcium Nitrate	3.5	25	125
Chromic (III) Acid	1	2.5	25
Chlorine*	3	7.5	60
Diluent (C10-C13 Isoalkanes) (Note 2)	5	35	200
• Decane (C10)	5	35	25000
• Undecane (C11)	6	40	200
• Dodecane (C12)	15	100	750
• Tridecane (C13)	60	400	500
Ethanol	500	3,500	15,000
Ethylene glycol	50	100	150
Ferrous sulfamate	3	5	25
Ferrous sulfate	7.5	12.5	350
Fluorine*	0.75	7.5	30
Hydrazine*	0.7	6.6	40
Hydrazine Monohydrate	0.0075	0.06	50
Hydrazine Nitrate	3	5	5
Hydrofluoric Acid*	1.5	15	40
Hydrochloric Acid*	4	30	200
Hydrogen Peroxide*	12.5	60	125
Hydroxylamine Nitrate	15	26	125
Iron	30	50	500

Table 8.3-1. TEELs (mg/m^3) Used as Chemical Limits for Chemicals at the MFFF (Note 1) (continued)

Name	TEEL-1	TEEL-2	TEEL-3
Isopropanol	1000	1000	5000
Manganese	3	5	500
Manganese Nitrate	10	15	500
Manganous Sulfate	7.5	12.5	500
Methanol*	262	1308	6540
Nitric Acid*	2.5	15	200
Nitric Oxide	30	30	125
Nitrogen Dioxide	7.5	7.5	35
Dinitrogen Tetroxide	15	15	75
Oxalic Acid	2	5	500
Potassium Hydroxide	2	2	150
Potassium Iodide	0.75	6	300
Potassium Nitrate	3.5	20	500
Potassium Permanganate	7.5	15	125
Silver Nitrate	0.03	0.05	10
Silver Oxide	30	50	75
Sodium Acetate	30	500	500
Sodium Carbonate	30	50	500
Sodium Hydroxide*	0.5	5	50
Sodium Nitrate	1	7.5	100
Sodium Nitrite	0.125	1	60
Sodium Oxalate	30	50	50
Sodium Sulfite	30	50	100
Sulfuric Acid*	2	10	30
Sulfamic Acid	40	250	500
Thenoyl TrifluoroAcetone	3.5	25	125
Tributyl Phosphate	6	10	300
Uranium Dioxide	0.6	1	10
Uranyl Nitrate	1	1	10
Xylene	600	750	4000

Table 8.3-1. TEELs (mg/m^3) Used as Chemical Limits for Chemicals at the MFFF (Note 1) (continued)

Name	TEEL-1	TEEL-2	TEEL-3
Zinc Stearate	30	50	400
Zirconium nitrate	35	35	50

* Values are based on Emergency Response Planning Guideline (ERPG) concentrations

Notes:

1. Temporary Emergency Exposure Limits (TEELs), Revision 18, are derived from approved methodologies developed by Department of Energy Subcommittee on Consequence Assessment & Protective Actions (SCAPA) and are identified in WSMS-SAE-02-0001.

2. The TEEL values for diluent represent the most conservative value in each category among the following primary constituents: n-decane, n-undecane, n-dodecane, and n-tridecane.

Table 8.3-2. Application of Chemical Limits to Qualitative Chemical Consequence Categories

Consequence Category	Worker	IOC
High	Concentration $\geq$ TEEL-3	Concentration $\geq$ TEEL-2 Uranium intake $\geq$ 30 mg
Intermediate	TEEL-3 > Concentration $\geq$ TEEL-2 Uranium intake $\geq$ 30 mg	TEEL-2 > Concentration $\geq$ TEEL-1 Uranium intake $\geq$ 10 mg
Low	TEEL-2 > Concentration Uranium intake < 30 mg	TEEL-1 > Concentration Uranium intake < 10 mg

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9. RADIATION SAFETY

The radiological protection program provides assurance that facility radiation safety measures protect the health and safety of workers and comply with the regulatory requirements of Title 10 of the Code of Federal Regulations (CFR) Part 20, *Standards for Protection Against Radiation,* and 10 CFR Part 70, *Domestic Licensing of Special Nuclear Material* during routine and nonroutine operations, including anticipated events. Public and environmental radiation protection is addressed in Chapter 10.

The potential for occupational exposure at the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) exists primarily as a result of processing plutonium (i.e., potential internal exposure from inhalation) and secondarily as a result of proximity to photon and neutron radiation sources (i.e., direct external exposure). The primary design features that limit exposure in accordance with as low as is reasonably achievable (ALARA) goals are automated and remote systems operation, confinement systems (e.g., gloveboxes, process cells, and ventilation), monitoring, alarms, and radiation shielding.

The radiological protection program applies to MFFF activities that manage radiation and radioactive materials, and that may potentially result in radiation exposure to facility workers and the individual outside of the controlled area (IOC). The radiological protection program guides the actions of personnel involved in radiological work at the MFFF.

9.1 RADIATION SAFETY DESIGN FEATURES

The MFFF design objectives, along with the programmatic measures, ensure that operation of the MFFF is in accordance with 10 CFR Parts 20 and 70, and ALARA principles. Engineering design features and management controls implemented during operation ensure that occupational doses are ALARA.

9.1.1 ALARA Design Considerations

9.1.1.1 Responsibilities for ALARA Design

The design function is split between the regulatory and engineering functions. The nuclear safety function within the regulatory function provides design criteria associated with radiation protection. The manager of the engineering function is responsible for implementation of radiation protection design criteria. Facility design engineers report to the manager of the engineering function. The nuclear safety function reviews the design, performs radiation protection analyses, and confirms that the design meets radiation protection design criteria.

Design personnel are qualified in radiation protection design and ALARA concepts, including personnel experienced in radiation protection, radiation shielding, and general radiation safety. Design personnel are trained to recognize potential radiation hazards and to minimize the effects of these hazards on operations.

The primary radiation analyses performed in support of the radiation protection design are radiation shielding calculations and occupational radiation dose assessments during routine and nonroutine operations.

9.1.1.2 MFFF Design and Design Activities

The MFFF design reflects ALARA principles. Specific ALARA considerations in the MFFF design include:

- Control of plutonium particulate to prevent inhalation by confining radioactive materials in process equipment and in gloveboxes
- Multiple-zone ventilation system design, sweeping from low to high potential contamination zones
- Continuous remote monitoring for airborne contamination in accessible areas with local and remote readout and alarm functions
- Use of automated and remotely operated equipment to minimize personnel exposure
- Provisions for removing radioactive material before most maintenance operations are included in facility maintenance procedures
- Shielding between radioactive sources and operators, according to the intensity, nature, and penetrating power of the radiation
- Design of structures, systems, and components (SSCs) that require a minimum of maintenance or repair, to minimize personnel stay time in radiation areas
- Shield wall penetrations between high radiation areas and personnel access areas are located and oriented so that there is no direct line of sight to the source(s), thus precluding streaming without reduction due to scatter
- Placement of piping containing radioactive fluids in nonaccessible pipe chases
- Placement of equipment requiring maintenance in separate shielded areas having a minimum of radioactive piping
- Placement of administrative, security, and radiation protection administrative activities away from radiation areas
- Areas of continuous occupancy are zoned to maintain dose rates at a low level while areas of higher dose rates are limited access
- Use of area radiation monitoring, with local and remote readouts and alarms to inform personnel of changing conditions.

9.1.1.3 Collective Dose Estimates

The design process includes an occupational dose assessment for the facility. Dose assessments are performed for each process unit with known personnel access requirements and are evaluated to determine reasonably achievable design enhancements to reduce exposures. Dose assessments were performed using guidance from U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 8.19, *Occupational Radiation Dose Assessment in Light-Water Reactor Power Plant — Design Stage Man-Rem Estimates*, and Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*.

The dose assessments take into account both direct and internal dose. The direct dose assessment was determined by dose rate analyses and a dose assessment process called the ABAQUES Method (see Section 9.1.4.6). The internal dose assessment was determined based on the MFFF design and review of MELOX and La Hague experience. The internal dose and direct dose sum meet MFFF's design goals and are ALARA.

9.1.1.4 Design Review Process

Competent personnel are responsible for the review of, and concurrence on, preliminary and final designs. The design reviews incorporate experience from the MELOX and La Hague plants. Project design reviews include ALARA evaluations to a level of detail commensurate with the potential radiation hazard. Recommendations made in the ALARA evaluations are tracked to completion as part of the review of design products.

The MFFF design incorporates applicable radiation protection experience from MELOX and La Hague, such as the following:

- Descriptions of process unit operations
- Personnel access times
- Source configurations
- Radiation dosimetry
- Radiation exposure problem areas
- ALARA design features and performance
- Contamination estimates
- Radiation monitoring design and operations
- Process unit shielding design
- Ventilation system design.

MELOX and La Hague are reference facilities for the MFFF design. Much of the MFFF facility design is the same as that used at the reference facilities. Occupational exposures at the MFFF facility should be similar to occupational exposure at the reference facilities, with adjustments to account for differences in radiation source terms, differences in shielding design, and personnel access requirements.

Radiation protection design improvements that have been made at the MELOX and La Hague facilities are incorporated into the MFFF facility design. For example, the grinding unit vacuum system minimizes loose contamination in the glovebox. Project team members have direct experience with the MELOX and La Hague facilities, and design documentation was available to the design team. Such improvements were incorporated to the maximum extent practical in the MFFF facility.

Continuing radiation safety (ALARA) design reviews for facility or process modifications are conducted during construction and operations. An appropriately qualified organization is responsible for reviewing facility or process modifications for the express purpose of maintaining exposures ALARA.

9.1.1.5 Other Design Considerations

Experience from the MELOX and La Hague facilities is incorporated into the MFFF design to ensure that the occupational exposure from the MFFF is maintained ALARA. Airborne and loose surface contamination is prevented during normal operations by plutonium recovery operations, glovebox design, and ventilation system design, to maintain inhalation dose ALARA. Most of the aqueous polishing (AP) process is installed in process cells. Entry to those process cells is physically prevented.

Design features such as automation and remote controls reduce the time spent in radiation areas. MFFF zone classification (see Table 9.1-1) minimizes occupational radiation exposure through access control and shielding design to meet exposure criteria.

The design minimizes the distribution and retention of radioactive material throughout plant systems by:

- Designing the process equipment containing radioactive material to confine the material to the maximum extent practical to reduce glovebox contamination
- Designing the gloveboxes to prevent accumulation of contamination and allow easy access for cleaning
- Using a vacuum system in gloveboxes so that airborne dust is collected in dust pots and the radioactive material is recycled.

9.1.2 Facility Design Features

This section describes the primary design features and equipment that directly or indirectly reduce radiation exposure for facility workers and provide monitoring capability.

9.1.2.1 Drawings and Descriptions

Facility drawings, process descriptions, and other facility documents associated with the radiation protection design include:

- Scaled drawings of the general arrangement of the facility with superimposed radiation zones based on expected worker occupancy
- Radiation shielding calculations that specify requirements for each process unit design
- A summary report of radiation protection design that provides definitions of the radiation sources, dose rates, and worker dose estimates for process units. The report identifies features relied on to reduce doses to ALARA, and shows how the design meets the requirements of 10 CFR Part 20 during routine and nonroutine operations including anticipated events.
- Location for radiation protection equipment both for fixed detectors and for storage of portable equipment
- General requirements and descriptions for radiation detectors and alarm systems

- Locations of permanent shielding and confinement design (e.g., penetrations, labyrinth seals, shield doors)
- Locations and access control points for radiation areas
- The controlled area, including the means to limit access to the controlled area as necessary
- The restricted area
- Change rooms, showers, and locker rooms
- Contamination control and waste minimization design features.

9.1.2.2 Radiation Sources and Exposure

The greatest potential for occupational radiation exposure at the MFFF is from plutonium inhalation. Therefore, the design incorporates multiple systems and barriers to prevent the release of radioactive material into personnel access areas. Depending on the stage in the process, confinement of radioactive material and worker protection is obtained by process vessels in cells (AP), gloveboxes (AP Sampling, Powder Area, and Pellet Process Area), or other sealed containers (fuel rods, containers). Gloveboxes are used to prevent personnel contamination. The gloveboxes are kept at a negative pressure with respect to the area occupied by personnel, to ensure that contamination will be contained in the event of a breach. A second ventilation system in the personnel access areas sends clean air through registers located near the ceiling toward the floor, providing a slow downwash of clean air at work stations, to minimize the potential for inhalation of contaminants. Airborne contamination and pressure are monitored to detect changes in containment barriers.

A second source of potential occupational radiation exposure is from direct exposure to radiation sources within gloveboxes. Although previous exposure rates are low (MELOX and La Hague), various design features have been implemented to attenuate ionizing radiation and to further limit operator exposures, including (1) limiting exposure times through automation and remote control of production workstations, and (2) placing shielding between radiation sources and operators.

For process cells in the AP Area, the primary feature is remote operations capability, with few operations performed in radiation areas. System sampling and inspections are designed to be performed from access areas outside of high radiation areas. Sources of radiation often can be removed from the work area prior to extensive work being performed. Routine access to process cells is precluded. Radiation shielding consists of multiple barriers — including concrete cell walls and borated concrete panels around process equipment for neutron absorption.

Access is restricted to process rooms containing gloveboxes. Few operations are performed in the process rooms themselves, thus free access is not necessary. These areas are protected against direct radiation from process equipment by thick concrete walls. Radiation shielding is included on the gloveboxes as necessary, and the facility is designed so that sources of radiation can generally be removed from the work area prior to extensive work being performed.

MOX Processing (MP) Area work is primarily performed in the process rooms, thus these rooms are routinely accessed. Radiation and pressure monitoring are performed to detect changes in the confinement barriers. Shielding is designed so that dose rates in radiation work areas are low, to accommodate required access. Existing data from the MELOX and La Hague facilities are used to estimate access requirements. Radiation shielding for both neutron and gamma sources is designed permanently into the glovebox system (inside the glovebox for large radiation sources when this does not impair operation, and outside the glovebox whenever practical). Shielding is separate from the confinement barrier to allow for changes, if needed, without the potential for spreading contamination. The radiation shielding concepts in the MFFF include the following:

- **AP cells** – thick concrete walls constitute the primary shielding
- **AP gloveboxes** – shielding on the gloveboxes as needed; limited access – primarily for sampling
- **MP gloveboxes** – shielding inside the gloveboxes when necessary; external shielding outside the gloveboxes in general based on access requirements
- **MP areas** – have separate areas for each process unit shielded by concrete and sealed to prevent the spread of contamination.

Standard shielding materials are used to attenuate radiation intensity at the worker. American National Standards Institute/American Nuclear Society (ANSI/ANS)-6.4.2-1985, R1997 is used as a reference for shielding material properties for performing calculations. Materials used for shielding include: leaded glass and plastic, borated polymers and plasters, carbon and stainless steel, cadmium, ordinary and borated concrete, and pourable plasters.

Glovebox design incorporates use of shielding to protect workers from direct radiation. Interior shielding is provided to ensure that radiation from specific sources is minimized. Glovebox walls incorporate appropriate shield materials to reduce worker exposures. Regular glovebox maintenance is conducted to preserve operability. Irregular, longer duration glovebox maintenance is scheduled at times when radiation sources are not present, to minimize radiation exposures to the maintenance personnel and to limit the potential for a release of airborne radioactive material.

Shielding design complies with 10 CFR §20.1406 requirements for the minimization of contamination and uses the MELOX and La Hague facility design experience for guidance. The design includes permanent shielding in the process rooms.

Project quality assurance applies to shielding design, procurement, installation, maintenance, and operation. Radiation shielding testing verifies the efficacy of installed shielding materials in meeting radiation shielding design goals and the direct dose regulatory requirements of 10 CFR Part 20.

Shielding materials are selected for the source term to effectively reduce dose rates to meet ALARA goals. Borated polymers are used for neutron attenuation, and stainless steel, leaded glass, and plastic are used for photon shielding in the glovebox units.

9.1.2.3 Ventilation Systems, Glovebox Design, and Waste Minimization

The design of ventilation systems and gloveboxes ensures that during routine and nonroutine operations and anticipated events, the airborne concentration in occupied operating areas remains well below the limits of 10 CFR Part 20, Appendix B. Engineering controls are preferred over the use of respiratory protection.

The MFFF process implements recycling and reuse for waste minimization. For example, the recycling process minimizes the quantity of plutonium in the final waste by using systems that return (recycle) radioactive material to previous steps of the main process. Liquid waste is minimized in the AP process by use of recycling to the maximum extent practical. Nitric acid is recovered by evaporation from the process and partly reused as reagent feedstock for the plutonium dissolution subprocess. Distillates from the evaporation process are collected and partly reused in the process. Spent solvent from the plutonium separation step is regenerated by washing with sodium carbonate, sodium hydroxide, and nitric acid to remove degradation products from organic compounds, including trace amounts of plutonium and uranium.

Solid waste is minimized by reuse of solid scrap material from fuel fabrication. Many other system design features perform contamination control, confinement, and associated waste minimization functions. The process design reduces the distribution and retention of radioactive materials throughout plant systems by using vacuum systems in the gloveboxes. Airborne dust is collected in dust pots in dedusting systems installed in the gloveboxes, and the material is recycled. These design features control contamination to ensure that secondary waste production is minimized during plant operation.

The air monitoring and warning systems are designed with a standby power supply. Uninterruptible power supplies are used to ensure air monitoring and warning systems are operable during a loss of power event. Alternatively, monitoring and warning systems will tolerate a temporary loss of power without loss of data.

9.1.2.3.1 Ventilation System Design

The ventilation (heating, ventilation, and air conditioning [HVAC]) system is designed to incorporate features that ensure workers are protected, to the greatest extent practical, from airborne radioactive material during normal and anticipated conditions. Many ventilation system design features described in this section also promote reduced airborne effluent releases, thus minimizing exposure to site workers and the IOC.

The HVAC systems maintain a negative pressure gradient between building confinement zones, and between the buildings and outdoors to ensure that airflow is from zones of lesser to greater contamination potential. Confinement zones are bounded by confinement system boundaries, across which a well-defined pressure gradient is maintained. This ensures that an air exchange, and consequently airborne contaminants, across a breach is also from zones of lesser to greater contamination potential. For example, air flows from clean areas (C1 or C2 zones) to the most contaminated areas (C4 zones) (e.g., gloveboxes), before being exhausted via high-efficiency particulate air (HEPA) filters to the plant stack. C4 zones are the primary confinement zones containing process equipment and enclosures. C3 zones are broken down into two levels

depending on the contamination hazard: C3a zones have a low occasional hazard, while C3b zones have a moderate hazard. C2 zones have a low occasional contamination hazard, and C1 zones have no potential for contamination.

In the AP and MP Areas, dynamic confinement of C4 zones is ensured by the Very High Depressurization Exhaust (VHD) system. In the AP Area, dynamic confinement of process cells within tertiary confinement is provided by the Process Cell Depressurization Exhaust (POE) system. In the AP and MP Areas, dynamic confinement of C3a and C3b zones within secondary confinement is provided by the High Depressurization Exhaust (HDE) system. In the AP and MP Areas, dynamic confinement of C2 rooms within tertiary confinement is provided by the Medium Depressurization Exhaust (MDE) system. For the AP process cells, the typical cascading sequence of pressure gradients between neighboring zones is as follows:

C1 → C2 → process cells

For the AP and MP Areas with gloveboxes containing dispersible material, the typical sequence is as follows:

C1 → C2 → C3a → C3b → C4

In both examples, leakage airflow is from high pressure to low pressure.

Airlocks for access are provided between zones. Cascading air from the cleaner areas through the airlock minimizes potential for migration of airborne contaminants into clean areas during personnel access.

Monitors and alarms indicate changes in confinement pressure to warn personnel so that appropriate action is taken. The instrumentation for a glovebox or enclosure ventilation system includes devices to indicate the differential pressure across the glovebox or enclosure, filter resistance, and the exhaust flow rate from the glovebox or enclosure. When glovebox or enclosure operations are not attended full time, an alarm will signify abnormal pressure at a location where operations personnel are stationed.

The ventilation systems operate continuously to protect personnel from exposure to airborne and transferable contamination. Redundancy ensures continuous operation of an HVAC system in the event of the failure of an active component (e.g., a fan or a damper) during normal or anticipated conditions. The Emergency Alternating Current (AC) Power system provides uninterruptible power to the VHD glovebox exhaust fans.

Room airflow in some rooms is designed to reduce the possibility of airborne radioactive materials being released in the vicinity of workers during abnormal conditions. Air is supplied above the worker and exhausted as close to floor level as possible. This design provides a "wash" across the worker, resulting in the air around the worker being maintained free of contaminants.

These design features minimize the potential that workers are exposed to airborne radioactive material during normal operations, maintenance, or anticipated events.

Airborne radioactivity monitoring and warning systems are provided for worker protection and safety. Systems are located near the glove ports and are placed to maximize sensitivity. The location was determined based on air flow characteristics. The monitoring and warning systems are connected to a data network, providing numerous communication links and readout capabilities. Alarms and instrument readouts are provided in the Health Physics Control Area (HPCA) of the Polishing and Utilities Control Room (PUCR), Emergency Control Rooms, and the Respiratory Protection and Health Physics Room (RM/HPR), which is used as the Operations Support Center during postulated events.

9.1.2.3.2 Glovebox System Design

The primary function of the glovebox is to protect workers from radioactive materials. The gloveboxes are considered primary confinement and are designed to meet ALARA objectives for both direct and internal radiation sources, and to ensure worker safety.

Glovebox design incorporates design techniques to minimize pockets and sharp corners. Smooth surfaces and rounded corners provide for ease of cleaning and recovery of material. This design reduces the localized collection of radioactive material and thereby reduces worker radiation exposure. Periodic cleaning inside the gloveboxes removes dust and minimizes contamination.

Gloveboxes are designed to withstand anticipated conditions (e.g., the design basis earthquake, over- or underpressure). The design ensures that, for anticipated conditions, personnel are provided appropriate protection from a release of radioactive material. Glovebox design is based on providing adequate airflow and sealing surfaces to preclude releases from the glovebox. Glovebox penetrations are designed with glove ports that are sealed to prevent release of contamination.

9.1.2.3.3 Design Features to Reduce Contamination and Waste Production

Many of the design features addressed in previous sections perform contamination control functions. In addition, the design reduces the distribution and retention of radioactive materials throughout plant systems by using a vacuum system in gloveboxes. Airborne dust is collected in glovebox dust pots, and the material is recycled.

Design features control contamination so that secondary waste production is minimized. These design features ensure that contamination is confined to specific areas and that contamination is minimized at the time the plant license is terminated, to facilitate eventual deactivation. The design incorporates extensive recycling for the materials exiting the main process (i.e., secondary waste streams of the AP process, and scraps not meeting MP process specifications). This recycling process is designed to minimize the quantity of plutonium in plant waste.

9.1.3 Radiation Protection Design Analysis

Potential occupational radiation exposure from external radiation sources is evaluated and minimized throughout the facility design process using general radiation zoning criteria, the ABAQUES dose assessment method, and design ALARA evaluations.

Each source of radiation within the facility is identified and included in the shielding analysis to estimate radiation dose-rate fields throughout the facility. Radiation sources are identified for each source configuration and "collapsed" for computer code input. Radiation transport codes are used to predict dose rates at work locations. Shielding is designed to meet radiation zone criteria and assures that exposures are below MFFF goals and ALARA.

Based on MELOX and La Hague operating experience, a residual source of contamination was conservatively estimated for loss-of-confinement and extremity dose analyses.

The occupational dose for normal operations and maintenance is assessed during the design phase. Significant occupational doses are evaluated for design enhancements to reduce the potential doses. ALARA analyses are performed to evaluate design alternatives to reduce occupational dose.

9.1.3.1 Source-Pertinent Information

Five primary radiation sources are used for radiation protection design: nonpolished plutonium, polished plutonium, raffinates, master blend, and final blend. Nonpolished plutonium, as received at the MFFF, contains daughter products from the original product that has decayed for about 40 years. As the facility nears the end of life, the original product received will have decayed about 70 years. These inventories are decayed to maximize the photon source term. Neutrons are produced by spontaneous fission and through alpha-neutron (α, n) reactions. Impurities associated with input materials are incorporated into the alpha-neutron (α, n) reaction for the unpolished source.

The sources identified were used to:

- Evaluate consequences of nonroutine events for the radiation protection design
- Provide input to shielding codes used in the design
- Establish design features, along with controls and responsibilities for restricted, controlled, and unrestricted areas
- Develop plans and procedures
- Assess occupational dose.

9.1.4 Shielding Evaluations

MELOX and La Hague operating experience is used throughout the MFFF design process to minimize occupational and public radiation exposure. Operating experience that defines the occupancy for each of the process units is used to estimate the occupational exposures for each glovebox. Radiation sources are determined for the MFFF. The redesign of some process units for process reasons and/or to optimize radiation protection is taken into account in the analysis. These sources are used to calculate the dose rates and thus establish the radiation shielding requirements. Process units that result in higher occupational exposure are reviewed to maximize productivity, minimize maintenance, and thus minimize radiation exposures. The

types of MELOX and La Hague data used for the MFFF design for personnel access requirements are as follows:

- Description of activities
- Proximity to radiation sources
- Definition of radiation sources
- Duration of activities
- Duration of time that hands are in the gloveboxes.

Permanent shielding is designed in the facility to lower dose rates to comply with 10 CFR Part 20 during routine and nonroutine operations and anticipated events. Radiation zone drawings are used to locate equipment.

Design goals for internal and direct doses are based on fractions of 10 CFR Part 20 limits. These were developed by making use of the design features and experience of the MELOX and La Hague facilities. Exposure data and the difference in the source terms between MELOX, La Hague, and MFFF material are used in setting these design goals. The permanent and temporary shielding developed as part of this design meets these design goals.

The Total Effective Dose Equivalent (TEDE) is the effective dose equivalent from external exposures plus the Committed Effective Dose Equivalent (CEDE) from internal exposures. Design goals for TEDE were established early in the design process for individual workers and are applied to facility operations (see Table 9.1-2).

Design drawings and descriptions of the shielding for high and very high radiation areas clearly identify the penetrations, shield doors, and labyrinths incorporated to meet the shielding design criteria. Radiation shielding analyses are used to verify the shielding for each process room, including the dose rates for each position workers are required to take to perform routine and nonroutine maintenance. This design is based on experience and the design features of the reference facilities. A radiation shielding test program will be implemented prior to the start of operations for protection of personnel from high radiation dose rates.

Several standard industry computer codes were used in the shielding calculations (e.g., Monte Carlo N-Particle [MCNP], SCALE, Perceval, SN1D). ANSI 6.1.1-1977, *Neutron and Gamma-Ray Fluence-to-Dose Factors*, flux-to-dose conversion factors were used to estimate dose rates. The 1977 version is more conservative than ANSI 6.1.1-1992 for MFFF's photon spectra.

The shielding design complies with 10 CFR §20.1406 requirements for the minimization of contamination and uses the reference facilities' design experience for guidance. The MFFF minimizes waste of shielding materials. The design includes permanent shielding in the process rooms.

9.1.4.1 Shielding Information for Each Radiation Source

Shielding is specified in each radiation shielding calculation to reduce dose rates and occupational doses to below levels established in the radiation zone drawings and below administrative goals. For those areas with estimated exposures greater than administrative goals,

an ALARA evaluation is performed to determine if design changes should be implemented to reduce the dose.

9.1.4.2 Criteria for Penetrations

Penetrations in shielding for high radiation sources are minimized in the design. For lower dose-rate sources, the impacts are analyzed in shielding analyses and determined to meet the ALARA goal. Radiation protection guidelines are provided to the penetration designers to meet recommendations of Regulatory Guide 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable*.

9.1.4.3 Shielding Materials

Standard shielding materials are used to attenuate the radiation intensity at the worker. Materials such as leaded glass, leaded polymers, borated concrete, borated polymers, borated plasters, stainless steel, and ordinary concrete are used. ANSI/ANS-6.4.2-1985, R1997, *Specification for Radiation Shielding Materials*, is used as the reference for shielding material properties for performing calculations.

9.1.4.4 Dose Assessment and ALARA Evaluations

The general design requirements established for the various radiological attributes addressed below include those that maintain exposures ALARA during normal operation and minimize exposures during off-normal conditions.

Potential occupational radiation exposure from external radiation sources were evaluated and minimized throughout the facility design process using general radiation zoning criteria, the ABAQUES dose assessment method, and design ALARA evaluations.

9.1.4.5 Radiation Zoning

Radiation zoning (see Table 9.1-1) was developed based on estimates of the access required for each area and radiation dose limits for personnel from 10 CFR Part 20. Shielding for the process units and access areas was designed to satisfy radiation zoning criteria. The final dose assessment verified that the facility can be operated within the occupational exposure limits of 10 CFR Part 20 and ALARA principles.

Radiation zone drawings show the design occupancy for radiation zones as follows: Zone Z1 is a continuous occupancy area for staff and visitors. Zone Z2 is a continuous occupancy area for trained workers. Zone Z3 is a limited occupancy area in which routine maintenance may be performed by trained workers. Zone Z4 and zone Z5 are conservatively estimated and are expected to be higher radiation areas. Access to zone Z5 radiation area is controlled in accordance with 10 CFR §20.1601.

Radiation shielding design as documented in the shielding analyses satisfies radiation zone criteria for restricted access areas. The design criteria for occupational exposures inside the MFFF are supported by the radiation zone criteria.

In zones Z1 and Z2, residence time is not restricted. The design basis maximum area radiation dose rates shown on radiation zone drawings allow continuous occupancy. The design basis maximum area radiation dose rate limit is the only shielding design criterion. Residence time is restricted in zones Z3, Z4, and Z5 of the AP Area, and access is permitted only intermittently.

Access to zone Z3 process rooms in the process areas is necessary for normal operations and routine maintenance. The annual dose equivalent for workers was evaluated with reasonable assumptions (in the form of time-motion studies). Access to zones Z4 and Z5 is restricted to nonroutine maintenance or intervention.

9.1.4.6 The ABAQUES Method

The facility design and resultant occupational dose are evaluated using the ABAQUES dose assessment method, which is similar to that provided in Regulatory Guides 8.19 and 8.34. Radiation shielding is selected to minimize personnel occupational exposures based on facility occupancy for normal operations and facility maintenance. Personnel exposures are estimated based on facility experience for access requirements, and standard shielding methods are used to estimate radiation fields. The method is iterated to minimize the number of personnel that have the potential of receiving doses in excess of the design goal. The general equation used to satisfy this prerequisite is as follows:

$$\frac{\sum_i f_i \times t_i \times DER_i}{\sum_i f_i \times t_i} \leq \frac{\text{design objective for individual doses}}{T} \qquad \text{(Eq. 9.1.4.6-1)}$$

where:

f_i = the frequency of each task associated with a given process unit or group of process units

t_i = the time of exposure for the task

DER_i = the dose equivalent rate for the task

T = the worker average estimated annual working time in radiation areas

$\sum_i f_i \times t_i$ = the total yearly duration of the tasks performed by the same work group associated with the process unit or group of process units.

The *DER*s are adjusted by varying the shielding thickness, and/or the operating conditions (operation duration and frequency) are changed to reduce the exposures to below the design goal. *T* is an estimate of the average time an individual spends in the radiation area per year based on industry operating experience. This is approximately 50% of the total working time, or 1,100 hours per year. The remaining time is associated with training, administrative duties, and work in the facility but outside of the radiation area. This approximation gives a rough estimate of the

number of personnel required to perform normal operations and routine maintenance for each process unit.

9.1.4.7 ALARA Evaluations

This process includes a preliminary estimate of the occupational exposure, an ALARA evaluation of the activities that produce exposures, and recommendations for design enhancements to reduce occupational exposures. Lessons learned from facility operations and industry guidance are used to evaluate potential design enhancements. ALARA cost-benefit analyses were performed to support design enhancements using NUREG/CR-0446, *Determining Effectiveness of ALARA Design and Operational Features.*

Occupational exposure data based on data from MELOX and La Hague were estimated. These data were used during the design phase to evaluate occupational radiation exposures and to recommend potential enhancements to the design to effectively reduce doses. Final design shielding calculations were performed to estimate dose rates and doses using the ABAQUES dose assessment method.

Several areas were further examined for cost-effective design changes to reduce the estimated occupational dose. Examples include:

- The receiving area, where transport casks with feed material are received and processed for counting and storage was evaluated. Impurities associated with the alternate feedstock feed material cause higher neutron radiation. Recommendations were made to reduce dose rates and personnel occupancy time to reduce potential doses.
- The assembly fabrication unit was evaluated for dose reduction. The MOX assembly is fabricated in a manner similar to a standard uranium fuel assembly. Design changes were made to automate the process as much as possible and to reduce worker time in the radiation area.

9.1.4.8 Predicted Occupational Doses

Estimated doses for operations meet 10 CFR Part 20 and ALARA criteria.

9.1.4.9 Dose Assessment Estimate

Occupational exposure was estimated for process units with expected occupancy for normal operations and preventive maintenance. MELOX and La Hague experience shows that outage maintenance contributes about 50% of the normal operating doses. The inhalation dose for MFFF is expected to be small.

9.1.4.10 Contribution from Internal Exposure

As previously noted, there are two primary sources of radiation risk to the MFFF worker: plutonium inhalation and direct radiation exposure. Plutonium inhalation is the most significant potential hazard at the MOX facility. Design engineers are instructed on the risks and the methods of controlling plutonium contamination. Process units that handle powder have the greatest potential for generating respirable particulate, releasing contamination, and causing

worker inhalation exposure. The process areas for these units provide radiation protection through the following multiple system barriers and controls:

- The operations for the units are controlled remotely and are automated to minimize access to the work area.
- The plutonium is contained in a sealed glovebox. This internal environment is kept under negative pressure relative to the worker environment. A leakage would be into the glovebox, thus preventing the release of contamination.
- Pressure within the glovebox is monitored.
- Glove ports are provided for maintenance access to the process equipment.
- When practical, process material is removed prior to maintenance activities.
- Workers evacuate the area upon radiation monitoring alarms.

Events that are expected to occur over the lifetime of the facility and their consequence are estimated and added to occupational exposure estimates.

Design features and management measures at the reference facilities are similar to MFFF; thus, the normal internal exposure received at the reference facilities, which is a small fraction of the total dose, is assumed to represent a reasonable estimate for the MFFF.

9.2 OPERATIONAL RADIOLOGICAL PROTECTION

The radiological protection program implements the requirements of 10 CFR Part 20, *Standards for Protection Against Radiation*, and the appropriate sections of 10 CFR Part 19, *Notices, Instructions and Reports to Workers: Inspection and Investigations*, and 10 CFR Part 70, *Domestic Licensing of Special Nuclear Material*. The radiological protection program implements the programmatic requirements necessary to ensure that radiological work activities are performed in a manner that protects the health and safety of workers, the IOC, and the environment.

The radiological protection program ensures the following:

- The individual worker's exposure to radiological hazards is ALARA.
- Personnel responsible for performing radiological work are appropriately trained.
- Personnel responsible for implementing and overseeing the radiological protection program are well qualified.
- The ALARA process is incorporated into the facility design, modifications, and work processes.
- Line management is involved and accountable for radiological performance.
- Radiological measurements, analyses, worker monitoring results, and estimates of public exposure are accurately and appropriately conducted.

- Radiological operations are conducted in a manner that controls the spread of radioactive material and reduces exposure to the work force and the public, and a process is used that maintains exposure levels ALARA.
- Employees have the authority and responsibility to stop radiological work activities suspected of being unsafe.
- Oversight is provided for radiography activities.

Contracted radiation technical support and services (e.g., instrument calibrations, dosimeters) are subject to controls under the Quality Assurance Program, which is described in Chapter 15.

MFFF is operated in a manner to not exceed radiological dose limits and to meet the goals of ALARA, as defined in 10 CFR Part 20. Radiological work activities, including those performed by subcontractors, meet the requirements of the radiological protection program.

Actions taken to maintain doses ALARA are documented as part of the radiological protection program.

9.2.1 ALARA Program

The purpose of the ALARA program is to maintain radiation exposures within regulatory limits and ensure that radiation exposure is ALARA. Line management and the work force are committed to this policy. The ALARA program is composed of the following:

- ALARA program description and procedures
- ALARA Committee
- ALARA Chairman
- ALARA program coordinator – An appointed member of the radiological protection staff who assists the ALARA Chairman in implementing the ALARA program.

9.2.1.1 Management Commitment

The responsibility for complying with radiological safety requirements and for maintaining radiation exposures ALARA starts with the individual worker and broadens as it progresses upward through the organization. Line management is fully responsible for the radiological performance of their personnel and takes necessary actions to ensure that personnel are properly trained and that performance is monitored and corrected as necessary. As part of their commitment to radiological safety, senior management ensures that the ALARA program is implemented and that line management is held accountable.

Management commitment to ALARA principles is communicated to plant personnel through policy statements, instructions to personnel, and similar documents, as well as by direct communication, training, and inspection of the workplace.

9.2.1.2 ALARA Committee

The ALARA Committee provides the focus and direction for improving the radiological protection program. The ALARA Committee includes the ALARA Chairman (who is a member of line management and nominated by senior management); the ALARA program coordinator; the manager of the radiological protection function; and personnel from line management, operations, engineering, criticality safety, and maintenance functions. Radiological protection personnel act as advisors to the committee. The ALARA Committee performs or receives the results of audits of the radiological protection program at least annually and reviews the results of the radiological protection organization's internal audits. The ALARA Committee evaluates major design activities, operations activities, or plant modifications that could affect radiation levels, doses, and radioactivity levels in liquid and gaseous effluents. The ALARA Committee considers the results of the Integrated Safety Analysis in determining whether further reductions in occupational radiation doses are reasonable. The ALARA Committee evaluates trend analyses and the adequacy and implementation of radiological performance (ALARA) goals. Reviews and recommendations of the ALARA Committee are tracked to completion.

9.2.1.3 Administrative Control Levels and Dose Limits

The objective of minimizing radiation exposure is to maintain individual radiation doses ALARA, but in all cases below regulatory limits. To accomplish this objective, administrative control levels are established below the regulatory limits to control individual and collective radiation dose (see Table 9.1-2). The administrative control levels are multi-tiered with increasing levels of authority required to exceed higher administrative control levels. Unless otherwise indicated, administrative control levels and dose limits are stated in terms of the TEDE.

9.2.1.4 Internal Audits and Assessments

Internal audits and assessments are performed under the Quality Assurance Program such that over a 12-month period, functional elements of the radiological protection program are evaluated for program compliance and implementation (10 CFR §20.1101(c), *Radiation Protection Programs*). The results of these evaluations provide valuable feedback to line management on those areas requiring additional management attention. Areas of review include, but are not limited to, access control (including proper posting, labeling, and operability of access controls), proper identification of restricted areas to prevent the spread of contamination, numbers and appropriate locations of step-off pads, change facilities, personal protective equipment facilities, personnel monitoring equipment, contamination and overexposure events, Radiation Work Permits (RWPs), instrumentation, and respiratory protection.

Radiological protection program performance is periodically evaluated using performance indicators measured against specific goals. These indicators are collective dose (person-rem), skin and clothing contaminations (number), radioactive material intakes (number), radioactive waste (volume), and airborne radioactive releases (curies). Trends in these areas provide information on the performance of the radiological protection program.

9.2.2 Radiological Protection Organization and Administration

The radiological protection function is independent of the operations and maintenance functions and has direct access to senior management. The radiological protection function provides relevant support to facility operations. The radiological protection function develops policies and procedures to ensure compliance with 10 CFR Part 20, and to ensure that the policies and procedures are implemented as necessary for compliance with 10 CFR §20.1101(b).

Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR Part 20 have the appropriate education, training, and skills to discharge these responsibilities. The radiological protection function, working with facility management, ensures adherence to the radiological protection program in operations and provides the required radiological support to the facility organization.

The manager of the radiological protection function (RPM) is responsible for setting radiological protection policy and for implementation of this policy. In addition, the RPM has the responsibility for planning, administering, and maintaining the radiological protection program — with support from line management — and reviews facility modifications and operations activities. The RPM ensures that radiological protection program elements are appropriately implemented and maintained through radiological policies, procedures, and documents. The RPM approves radiological protection policies and procedures.

The RPM ensures that staffing for the radiological protection function is adequate to conduct routine radiation functions in a timely manner and ensures radiation requirements can be met during routine operations and nonroutine operations, such as anticipated events and accidents.

The RPM is an experienced professional in radiological protection and is familiar with the design features and operations of the facility that affect the potential for exposures of persons to radiation.

The RPM has the technical competence and experience to establish effective radiological protection programs and the supervisory capability to direct the implementation and maintenance of the radiological protection program.

The RPM has a minimum of a Bachelor's degree, or equivalent, in science or engineering, and has at least five years of experience in radiological protection. Certification by the American Board of Health Physics or an additional five years of relevant experience provides equivalency to the degree requirements. (Management may waive specific qualifications for the RPM when education, experience, certifications, and overall qualification of the supporting staff meet the above requirements.)

The senior staff of the radiological protection function includes health physicists and other professionals with four-year degrees in science, engineering, or equivalent (as defined above for the RPM) and at least one year of experience in applied radiological controls at an operating nuclear facility.

Radiological support personnel provide radiological protection and radiological engineering, dosimetry, bioassay, independent oversight, instrumentation and calibration functions. These personnel have a high school diploma or equivalent, and technical qualifications pertinent to their assigned duties.

9.2.3 Radiation Safety Procedures and Radiation Work Permits

The primary methods used to control workplace exposure are operating procedures and facility and equipment design features. These controls are augmented with the use of area entry/exit requirements to control access to and from radiological areas, and RWPs to control radiological work. Proposed maintenance and modification plans are reviewed to identify and incorporate radiological protection requirements.

RWPs are issued and controlled in accordance with approved radiological protection procedures that require RWPs to be used for specific purposes only, and are reissued when there are significant changes in the task, or changes that affect the safety of workers. RWPs include a list of safety requirements for authorized work, and include at least the following, as applicable:

- The identification of personnel working on the task
- Expected radiological conditions (radiation, contamination, and airborne levels)
- Type and frequency of monitoring and dosimetry (e.g., continuous air monitor [CAM], self-alarming dosimetry)
- Estimated doses for the authorization
- Limiting doses for the authorization
- Allowable stay times
- Special instructions or equipment (e.g., mockup required, special shielding required)
- Hold points or monitoring points, if applicable
- Personnel protective equipment requirements
- Authorization signature and date
- Actual doses, time, or other information resulting from the completed work authorization recorded on the RWP
- Expiration/termination date of the RWP
- Sufficient information on RWPs to allow independent inspection and reconstruction of the circumstances necessitating the RWP, the factors included, and the results.

Radiological protection staff designated by the RPM review and approve RWPs. Other RWP approvals may include other organizational groups' reviews and/or approvals, when appropriate, to ensure that provisions of the RWP or related documentation address potential hazards (including nonradiological hazards) and compliance with applicable regulations. Other organizational group procedures that involve the use of licensed materials without an RWP require review and approval by the RPM.

Administrative controls (RWP expiration/termination date) ensure RWPs are not used past their termination dates. Procedures define the types of records to be kept, retention time for these records, and the final disposition of the RWP. The record system allows independent auditors to reconstruct the circumstances necessitating the RWP, the factors included, and results. Routine (e.g., long-duration maintenance) RWPs are reviewed periodically to identify improvements in worker protection.

Procedures and administrative controls ensure current copies of radiological protection procedures and RWPs are provided to appropriate personnel.

Radiological protection procedures and RWPs are developed, maintained, and used under quality assurance (QA) controls.

9.2.3.1 Radiological Work Planning

Work planning is the responsibility of line management, with support from the radiological protection organization. Radiological surveys are used to develop radiological protection requirements and are documented on the RWP. Specific radiological controls based on the surveys, and from formal ALARA reviews that were performed because established planning thresholds were exceeded, are incorporated into the work documents.

9.2.3.2 Radiation Area Access Control

Specific requirements for entering and exiting radiation areas are established. Radiation safety training commensurate with the hazards and required controls is required before unescorted access to radiation areas is permitted. The primary control for entry into radiation areas is the RWP, which is augmented by signs and barricades.

Administrative procedures implement radiation area access controls. These procedures address measures implemented to ensure the effectiveness and operability of entry control devices, such as barricades, alarms, and locks. Periodic inspections of the physical access controls to high and very high radiation areas are made to verify controls are adequate to prevent unauthorized entry. Worker access controls for high and very high radiation areas meet the requirements of 10 CFR §20.1601 and §20.1602.

9.2.3.3 Radiological Work Controls

Positive control of personnel is established through RWPs. Only trained and qualified personnel who have the information available to properly respond to the radiological conditions that they will encounter during the work activity are allowed to enter the restricted area unescorted. In special circumstances, specialists who have not completed unescorted access training may be allowed escorted access to perform specific tasks, with permission granted by the RPM.

The RWP is the administrative mechanism used to establish radiological controls for intended work activities. The RWP informs employees of area radiological conditions and entry requirements, and provides a mechanism to relate employee exposure to specific work activities.

9.2.3.4 Posting and Labeling

Posting and labeling of radiation areas, high radiation areas, and radiologically contaminated areas, equipment, and material are used to alert personnel to the radiological status of the item or area, and to prevent an inadvertent dose to the worker. This includes the use of the standard radiological posting and labeling to meet the requirements of 10 CFR Part 20 Subpart J, and posting signs that are clear and conspicuous. As stated in Chapter 1, an exemption request has been submitted related to container labeling requirements.

9.2.3.5 Release of Materials and Equipment

Material and equipment that are contaminated or potentially contaminated are considered contaminated until they are surveyed and released. This ensures that no contaminated material or equipment is inadvertently released. Movement of material and equipment from contamination areas, and between controlled areas and release of material and equipment from controlled areas, and from the site, is controlled. See Table 9.2-1 for contamination limits.

9.2.3.6 Sealed Radioactive Source Accountability and Control

Radioactive sealed sources are controlled by accountability and monitoring requirements to prevent loss or unintentional exposures. Sealed sources are leak tested in accordance with procedures that include limits and actions to be taken if limits are exceeded. Frequency of leak testing is described in program documentation. Sealed sources in excess of limits in 10 CFR §20.1601 or §20.1602, when not in use, are kept in locked storage areas where access is controlled by the RPM.

9.2.3.7 Receipt of Packages Containing Radioactive Material

MFFF ensures that appropriate controls are implemented from the time of package receipt to final destination. Receipt and offsite transfer of radioactive materials is conducted in accordance with 10 CFR 20.1906, 10 CFR 71 and 49 CFR 171 – 178. Unauthorized access to packages is prevented to ensure that radiation dose is ALARA.

9.2.4 Radiation Safety Training

Radiation safety training is commensurate with the employee's duties. Standardized courses are used to the extent practical and are supplemented by facility-specific information. Personnel and visitors entering restricted areas receive either radiation safety training, or are provided a general indoctrination in site-specific safe practices and are escorted by an individual who has received such radiation safety training. To be granted unescorted access to the MFFF restricted area, individuals are required to pass site-specific general employee training.

Radiation safety training addresses the following topics, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards:

- Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure
- Basic radiological fundamentals and radiological protection concepts
- Controls, limits, policies, procedures, alarms, and other measures implemented at the facility to control doses, including both routine and emergency actions
- Identification of potential loss of confinement events
- Individual rights and responsibilities as related to implementation of the facility radiological protection program
- Individual responsibilities for implementing ALARA measures
- Individual exposure reports that may be requested.

Individuals likely to receive an occupational dose in excess of 100 mrem in a year will be instructed on procedures and equipment used to maintain exposure ALARA.

Examinations are used to demonstrate satisfactory completion of theoretical and classroom material. Examinations are written; however, the RPM may approve alternatives to accommodate special needs. Alternative examinations are equivalent in content to written examinations. Trainees acknowledge in writing that the training was received and understood. Records of the most recent training and testing are maintained.

Training addresses both normal and abnormal situations in radiological protection.

General employee training is completed annually. Changes to the program are incorporated as they are identified and a decision made if retraining prior to the annual period is needed.

Radiological worker retraining also is completed annually.

MFFF site-specific training and refresher training includes changes in requirements and updates of lessons learned from operations and maintenance experience and occurrence reporting for the MFFF site.

9.2.5 Air Sampling

Airborne radioactivity monitoring uses air samplers and/or CAMs, with usage based on working conditions. Frequency of air sampling is based on area conditions and planned activities. Counting techniques, action levels, and alarm setpoints are described in radiological programs and procedures. Controls minimize internal exposure to the radiation workers as part of the overall ALARA program. The estimation of internal dose is based on airborne radioactivity concentrations. In the event of suspected high exposure, the internal dose is verified from bioassay data.

Air monitoring equipment is used in situations where airborne radioactivity levels can fluctuate and early detection of airborne radioactivity could prevent or minimize inhalation of radioactive material by personnel. Selection of air monitoring equipment is based on the specific job being

monitored. Air monitoring equipment includes portable and fixed air sampling equipment, and CAMs.

Air sampling equipment is used in occupied areas where, under normal operating conditions, a person is likely to receive an annual intake of 2% or more of the specified annual limit on intake (ALI) value (40 Derived Air Concentration [DAC]-hours).

Real-time (or continuous) air monitors are used to provide early warning to individuals of events that could lead to substantial unplanned exposures to airborne radioactivity. Such exposures could result from a breakdown of engineered controls or improper establishment of boundaries during work that creates airborne radioactivity. Real-time air monitoring detects and provides warnings of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

Air sampling equipment is positioned to measure air concentrations to which persons are exposed.

Air monitoring equipment is calibrated and maintained at a frequency specified in the radiological protection program. CAMs are capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.

Continuous air monitoring equipment has sufficient sensitivity to alert personnel that immediate action is necessary to minimize or terminate inhalation exposures.

The proper operation of continuous air monitoring equipment is verified by performing an operational check. Operational checks include positive air-flow indication, non-zero response to background activity, and internal check sources (or electronic checks when available). Continuous air monitoring equipment is verified by checking for instrument response with a check source.

Air sample results are evaluated as quickly as practical for evaluation of the need for respiratory protection, area evacuation (if necessary), worker intake, and worker relief from respirator use.

9.2.6 Contamination Monitoring and Control

Contamination monitoring and control measures prevent the movement of radioactive contamination from controlled areas to uncontrolled areas, and “clears” personnel and equipment when leaving contaminated areas. Radioactive contamination is controlled by using engineering controls, by containing contamination at the source, by monitoring, and by promptly decontaminating areas that become unintentionally contaminated. The use of personnel monitoring equipment is required when personnel leave a known contamination area. Personnel are considered contaminated if contamination levels are detected in excess of levels given in Table 9.2-1.

To monitor and control contamination, instrumentation appropriate for the contaminant is used; most often this will be an alpha-sensitive instrument.

Surveying contaminated areas is performed to determine the level of contamination. Survey results are also used to determine if postings are correct, if additional controls are required, and to determine the appropriate personnel protective equipment.

Contamination surveys, investigations, corrective actions, and reviews (along with deficiencies) are documented. The radiological protection organization reviews this documentation for possible trends and needed corrective actions. Contaminated areas and contamination levels are tracked as part of ALARA goals.

A surface is considered contaminated if either the removable or total surface contamination is above the levels in Table 9.2-1. Contamination surveys incorporate techniques to detect both removable and fixed contamination. Initially, contamination surveys (i.e., instrument, swipe and large-area wipes) are conducted in the Radiological Control Area established for the control of contamination, and other areas with the potential for becoming contaminated. After historical data have been collected, the frequencies of surveys are adjusted to optimize resources.

To prevent internal contaminations, procedures and policies restrict eating, drinking, and smoking within the Radiological Control Area.

The MFFF design is an enclosed system and features low contamination estimates, which allows protective clothing requirements to be optimized. Depending on the contamination at the work location, the minimum type of clothing is either a lab coat for lab areas, or plastic (disposable) coveralls for minor maintenance.

Personnel wear protective clothing during the following activities:

- Handling contaminated materials with removable contamination in excess of prescribed levels
- Work in contamination, high contamination, and airborne radioactivity areas
- As directed by the radiological protection organization, or as required by an RWP.

In cases of skin contamination, decontamination is performed by radiological protection technicians, with wounds treated by the medical staff. As a minimum, nonabrasive methods, such as soap and water, are used. In cases of dry contamination or nondiscrete radioactive particles, masking tape is used.

Once materials or equipment have entered the Radiological Control Area, surveys are required before releasing material or equipment. See Table 9.2-1 for contamination limits.

Radiological Control Zones (RCZs) are set up at work sites where personnel change into appropriate protective clothing prior to entering the RCZs. Used clothing is deposited in containers at the RCZs, and personnel check themselves for contamination prior to exiting the work area.

9.2.7 Direct Exposure Control

Personnel working at the MFFF are exposed to both photon and neutron radiation. The criteria for personal dosimetry are to:

- Measure both photon and neutron radiation from the primary isotopes of plutonium, uranium, and americium
- Provide reproducible results.

The direct exposure controls provide the following:

- Exposure monitoring
- Dosimeters and their processing
- Dose determinations
- Dose record maintenance
- Dose reporting
- Records maintenance.

The purpose of direct exposure controls is to ensure that the radiation worker doses do not exceed dose limits. Controls include:

- Measurement of the direct radiation dose received by workers using a dosimeter
- Control, as practical, of personnel who have received radiopharmaceuticals
- Planned special exposures
- Exposure limit for minors and the public
- Radiological protection for an embryo/fetus.

Personnel dosimetry is required for the following:

- Personnel who are expected to receive an annual external whole body dose greater than 100 mrem, or an annual dose to the extremities, or organs and other tissues (including lens of the eye and skin), greater than 10% of the corresponding limits specified in Table 9.1-2
- Declared pregnant workers who are expected to receive from external sources a dose equivalent of 50 mrem or more to the embryo/fetus during the gestation period
- Visitors, and public expected to receive an annual external whole body dose equivalent of 50 mrem or more in a year
- Minors for whom access and monitoring requirements are approved by the RPM
- Neutron dosimetry provided when a person is likely to exceed 100 mrem annually from neutrons.

Thermoluminescent Dosimeters (TLDs) and Albedo (reflected) TLDs are the primary measuring devices at the MFFF. These dosimeters have the appropriate range and sensitivity to accurately measure exposures from plutonium and the other primary isotopes. Personal dosimeters are

analyzed at a frequency described in approved procedures. Dosimetry is processed and evaluated by a processor accredited by the National Voluntary Laboratory Accreditation Program. TLDs are the source of exposure information for records. See Section 9.2.13 for exposure records. Radiation protection program policies and approved procedures establish action levels for personal dosimetry analyses results.

9.2.8 Internal Exposure Control

Internal exposure controls monitor workplace activities for potential and actual intakes of radioactive material. Both discretionary and nondiscretionary bioassay sampling are employed to monitor internal uptakes and to determine the quantity of the uptake.

Baseline bioassay monitoring of personnel who are likely to receive intakes resulting in a CEDE greater than 100 mrem is conducted before they begin work that may expose them to internal radiation exposure. The 100 mrem action level is difficult to achieve; therefore, workplace monitoring is also used to identify potential intakes so that special bioassay monitoring can be initiated.

Routine bioassay monitoring methods and frequencies are established for personnel who are likely to receive intakes resulting in a CEDE greater than 100 mrem.

Termination bioassays are required when a person who participated in bioassay monitoring terminates employment.

Bioassay analyses are also performed when any of the following occurs:

- Facial or nasal contamination is detected that indicates a potential for internal contamination
- Airborne monitoring indicates the potential for intakes exceeding 100 mrem committed effective dose equivalent
- Upon direction of the radiological protection organization when an intake is suspected.

Levels of intakes that warrant the consideration of medical intervention are based on site-specific radionuclides. The effectiveness of medical intervention, such as blocking or chelating agents, is documented using bioassay results.

A preliminary assessment of the intakes detected is conducted prior to permitting an employee to return to radiological work.

Internal dosimetry relies on radionuclide standards from, or traceable to, the National Institute of Standards and Technology (NIST).

Summation of the internal dose includes the methodology that evaluates the doses from inhalation, oral ingestion, and an intake through wounds or absorption through skin.

Interpretation of bioassay results and subsequent dose assessments includes the following:

- Characteristics of the radionuclide, such as chemical and physical form
- Bioassay results and the person's previous exposure history
- Exposure information, such as route of intake, and time and duration of exposure
- Biological models used for dosimetry of radionuclides
- Models to estimate intake or deposition and to assess dose
- Minimal Detection Levels for the potential primary contaminants – plutonium, uranium, and americium – based on implementation of American National Standard HPS N13.30-*1996 Performance Criteria for Radiobioassay*
- Coordination between the radiological protection organization and medical personnel for doses that may require medical intervention
- DAC and ALI values – presented in Table 1 of 10 CFR Part 20, Appendix B; used to determine the individual's dose and to demonstrate compliance with occupational dose limits
- In estimating exposure of individuals to airborne radioactive materials, the respirator protection factor for respiratory protection equipment worn is considered.

Radiation protection policies and approved procedures establish action levels for internal contaminations. Bioassays are documented in accordance with the QA controls. Bioassays analytical quality control is described in the appropriate laboratory manual. Analytical procedures are consistent with national or international consensus standards or have equivalent or superior performance to such methods based on industry accepted methodologies. Analytical instrumentation is standardized and calibrated in accordance with the manufacturer's recommendations. Calibration standards are traceable to NIST.

9.2.9 Summing of Internal and Direct Exposure

The maximum doses allowed for occupationally exposed workers are contained in 10 CFR §20.1201. These limits apply to radiation workers 18 years of age or older. These limits are expressed in units of dose equivalent (DE) in rem and Sv. Internal dose to a specific organ is given as committed dose equivalent (CDE), while the internal dose relative to a whole-body exposure is given as CEDE. Direct dose is expressed as deep dose equivalent (DDE), shallow dose equivalent (SDE), and lens of the eye dose equivalent (LDE). Extremities are considered to be the hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

The annual occupational exposure limits from 10 CFR Part 20 are:

- Total (CEDE + DDE) = TEDE 5 rem (0.05 Sv)
- Lens of Eye (LDE) 15 rem (0.15 Sv)
- Other Organs (CDE + DDE) 50 rem (0.5 Sv)
- Skin or Extremity (SDE) 50 rem (0.5 Sv).

9.2.10 Respiratory Protection

Using ALARA concepts, the use of respiratory protection is minimized to ensure that the TEDE dose is optimized for the work activity. Specialized training and a medical evaluation are required for individuals required to wear respiratory protection.

It is MFFF policy to limit the intake of hazardous material by its workers to ALARA. Engineering and process controls (contamination control, use of containments, ventilation, and other technology) are used to the extent practical to minimize airborne hazards. When these are not practical to control levels below the appropriate limits for a hazard, the radiological protection organization will limit intake by control of access, limitation of exposure times, and use of respiratory protection equipment.

Respiratory protection is worn (unless ALARA analysis indicates TEDE for an operation would be lowered by not wearing respiratory protection) when air sample analysis indicates concentrations equal to or greater than the 20% of the DACs listed in 10 CFR Part 20, Appendix B.

Respiratory protection is selected to give a protection factor greater than the multiple by which the peak concentration exceeds the DACs listed in 10 CFR Part 20, Appendix B.

Use of respiratory protection is reduced to the minimum practical by implementing engineering controls and work practices to contain radioactivity at the source.

Equipment used is within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection), when needed.

Adequate numbers and locations of respiratory protection equipment are available.

9.2.11 Instrumentation

Fixed and portable radiological protection instrumentation used for the radiological protection program are calibrated and maintained to ensure accurate and reproducible results.

MFFF radiological protection equipment comprises a broad spectrum of analytical instruments used to determine the presence of radioactive material and to quantify the amount of contamination. Instrumentation ranges from gross measurements to specific isotopic analytical analyzers that can determine the constituents and quantity of each isotope. The instrumentation also includes installed personnel monitors and hand-held survey equipment.

Airborne contamination monitors are installed to detect barrier failure. These monitors are placed in each room where either personnel access is allowed or that contains the first confinement barrier. In rooms with no routine personnel access, airborne contamination monitors obtain air samples taken from the ventilation exhaust ducts exiting rooms (cells) as appropriate.

To ensure that workers are provided adequate monitoring, there may be more than one CAM in a room. The actual number of CAMs is determined based on the anticipated number of operations

and the potential for an uptake. Where there is a potential for airborne contamination, a monitor is installed so that the workers are provided coverage. The initial number and location of monitors is based on MELOX and La Hague experience.

A person working in a glovebox (i.e., hands/arms extended into glovebox gloves) has an airborne contamination monitoring device (i.e., CAM) located in close proximity to the breathing air zone. To ensure coverage at glovebox workstations, some CAM sample heads are movable. In addition to the CAMs provided for workstations, CAMs are also strategically placed in routinely occupied areas surrounding gloveboxes. Readout and alarm monitors are located in the PUCR and the RM/HPR. The system also provides an alarm in the glovebox room and in the airlocks for the glovebox room if the airborne contamination exceeds preset limits. Portable CAMs are available for use during maintenance and provide additional coverage.

Alarm setpoints are provided at two distinct levels to enable the worker to take appropriate action if a release should occur. The lower (first) setpoint provides a local warning of increasing airborne contamination so that the worker can exit the room or don appropriate respiratory protection equipment. This alarm also warns other workers outside the room that there is an increase in airborne contamination and that they should not enter the room without respiratory equipment. The higher (second) alarm setpoint provides local alarm and readout, indicating that personnel are in danger and that immediate actions are required to provide protective measures to the workers. This setpoint is less than the 10 CFR Part 20, Appendix B limit, but above the warning level. The alarms have remote readouts in the PUCR and the RM/HPR so that the process can be terminated and corrective actions can be initiated to stop the release.

During maintenance activities when a glovebox or a system boundary is opened, portable air samplers are used to monitor personnel inside contamination control enclosures. The use of portable monitors allows for closer supervision of the airborne activity in the area of the work.

The radiation monitoring system is designed to monitor MFFF workspaces, through the use of general area radiation monitors (ARMs) and airborne radiation monitors, to protect the health and safety of personnel. This design is accomplished by identifying occupancy requirements and their respective environments (i.e., considering the potential for elevated airborne radioactivity or changes to workspace radiation levels).

The MFFF radiation monitoring system consists of general ARMs (neutron and gamma) and airborne alpha contamination monitors. This combined monitoring system allows for the detection of the possible radiation that a worker may be exposed to during normal and abnormal operations. The system also provides trending information so that increasing radiation levels may be determined to facilitate removing the sources of radiation exposure or limiting the time that a worker might be in the general area.

The radiation monitoring system monitors and tracks area background radiation levels for trending purposes. The CAMs take representative and timely measurements of radioactivity concentrations in air at workstations and general work areas to maintain worker exposures ALARA.

General area ARMs are provided to monitor the neutron or gamma radiation levels in rooms containing gloveboxes, production units, and the laboratory. ARMs are also placed where radiation workers are likely to be stationed or perform routine operations. These monitors detect and warn workers of an unexpected increase in the radiation level of the general area. Either a neutron or gamma area monitor is provided, depending on the primary source of radiation. The monitors detect increases in radiation environments caused by significant variations in quantities of radioactive materials, including radiation from nearby gloveboxes and conveyors, loss or failure of shielding, or an unexpected source of direct radiation.

ARMs inform radiological protection personnel and control room personnel of radiation in excess of the limit designated for an area (i.e., radiation zone limit) and/or a limit determined to be ALARA. Also, direct personnel monitoring may be performed through the use of worker-alarming dosimeters.

Gamma and/or neutron ARMs monitor the intensity of radiation in areas where significant quantities of plutonium are stored and/or handled. Selected monitors have pre-selectable trip settings with audible annunciation and provide electronic signals for remote alarms.

9.2.11.1 Types of Instrumentation

9.2.11.1.1 Alpha/Beta Counters

Due to the nature of plutonium, the ability to detect minute quantities of plutonium requires the use of sensitive equipment. The MFFF radiological protection equipment is capable of detecting extremely low levels of alpha contamination in a relatively short counting-time cycle.

The radiological protection laboratories, MP Area, and AP Area are equipped with alpha/beta counters to enable the processing of swipes and airborne contamination surveys on a continuous basis. Additional counters are located as necessary to support incoming radioactive material and shipments of waste, fuel, and excess materials.

9.2.11.1.2 Isotopic Analytical Equipment

The laboratories are equipped with instrumentation capable of quantifying the radioactive material on swipes, air samples, and other sample configuration. When necessary, the detector portion of the instruments is installed in counting shields to reduce the background effects and minimize background counts.

9.2.11.1.3 Personal Surveys Between Contaminated Areas

At transitions between contaminated areas, personnel are monitored for contamination. Personnel monitoring equipment is placed as close to the source as practical to ensure that contamination is controlled close to the source.

9.2.11.1.4 Whole Body Contamination Monitors

Prior to exiting MFFF production areas, personnel are surveyed at control points by multidetector personnel contamination monitors to ensure that no contamination leaves the area.

9.2.11.2 Instrument Calibration

Radiological instruments are used only to measure the radiation for which their calibrations are valid and follow the requirements contained in ANSI N323 for radiological instrumentation calibration. Calibration sources are traceable to NIST.

Calibration procedures are developed for each radiological instrument type and include frequency of calibration, pre-calibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements.

Radiological instruments are calibrated based on instrument performance and manufacturer's recommendations. The effects of environmental conditions, including interfering radiation, on an instrument are known prior to use. Operational checks are performed on continuously operating radiation protection instruments at a frequency based on instrument performance and manufacturer's recommendations.

When necessary to use an instrument in an application other than that envisioned by the manufacturer, the instrument is adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

Instruments bear a label or tag with the date of calibration and date calibration expires.

Instruments whose "as found" readings indicate that the instrument may be out of calibration are reported to the radiological protection organization. The radiological protection organization reviews surveys performed with the instrument while it was out of calibration.

Calibration facilities perform inspections, calibrations, performance tests, and calibration equipment selection in accordance with the recommendations of ANSI N323, *Radiation Protection Instrumentation Test and Calibration*, and take the following actions:

- Locate calibration activities in a manner to minimize radiation exposure to operating personnel and to personnel in adjacent areas
- Minimize sources of interference, such as backscatter and non-ionizing radiation, during the calibration of instrumentation and correct for interference as necessary
- Operate in accordance with the referenced standards
- Generate records of calibration, functional tests, and maintenance in accordance with the referenced standards.

9.2.11.3 Instrument Maintenance

The radiological protection program includes preventive and corrective maintenance of radiological instrumentation. Preventive and corrective maintenance are performed using components and procedural recommendations at least as stringent as those specified by the manufacturer of the instrument. Radiological instruments undergo calibration prior to use and following preventive or corrective maintenance, or adjustment that voids the previous calibration. A battery change is not considered maintenance.

9.2.11.4 Radiological Protection Work Areas and Labs

The radiological protection working spaces consist of radiological protection laboratories and a radiological protection storage room, which contain instruments and areas where technicians may prepare their survey results and store hand-held instruments. These laboratories contain multisample alpha/beta counters, as well as hand-held survey instruments, portable air samplers and isotopic analyzers. The space allows personnel to perform surveys, count the samples, perform isotopic analyses, and record results.

Level 3 of the Shipping and Receiving Area contains the access control point into the Radiological Control Area, which serves as the egress point for both the MP and AP Areas. This area has the personnel contamination monitors and the Decontamination Area / Contaminated First Aid Area. The Decontamination Area / Contaminated First Aid Area contains a shower and sinks to perform minor decontamination of individuals, and supplies to treat minor injuries.

The Technical Support Building has three rooms dedicated to radiological protection activities:

- **RM/HPR**– Houses the respiratory equipment and issue area for the MFFF. This room provides for the minor repair of respiratory protection and storage of spare equipment and emergency supplies.
- **Clean Anti-Contamination Storage Room** – Provides storage for anti-contamination clothing to be used during maintenance activities.
- **Locker Room Area** – Contains storage racks for respiratory protection and dosimetry devices. Space is provided for an increase in staff during maintenance outages.

In the HPCA and the RM/HPR, there are visual displays of alarms and radiation levels for the MFFF radiation monitoring equipment. These visual displays provide identification of specific alarms and the locations of the radiation monitors in the workplace.

The radiation monitoring system uses trending software to identify increasing direct radiation levels over a period of time. The system provides the initial warning of increasing radioactivity in gloveboxes and production rooms and releases to the environment.

9.2.12 Significant Exposure or Contamination Response Capabilities

Personnel assigned to MFFF have dosimetry that can be used to determine if significant exposures have occurred. Personnel within the MFFF process areas wear a TLD, and an electronic pocket dosimeter. The electronic pocket dosimeter may be exposed to an excessive amount of radiation beyond the capabilities of the instrument. In that case, significant exposure dosimetry will be used to quickly identify personnel with high levels of exposure. Response personnel are trained to survey personnel, including significant exposure dosimetry, for indications of significant exposures. TLDs can be rapidly processed for a more accurate exposure determination. The combined readings are then used to determine the necessity of long-term medical treatment.

Personnel involved in a significant exposure event will initially be transported to the Decontamination / First Aid Room located in the Shipping and Receiving Building. MFFF radiological protection staff will then initiate treatment and decontamination efforts to remove gross amounts of contamination as necessary.

Savannah River Site (SRS) staff physicians and nurses are trained in the proper treatment of high levels of exposure and contamination. The SRS is equipped with medical facilities, ambulances, and technicians to rapidly provide appropriate medical treatment.

9.2.13 Exposure Records

Complete and accurate radiological protection records of areas, including the records of individuals who work in or visit them, are maintained in accordance with 10 CFR Part 20, Subpart L. Reports are formatted in accordance with 10 CFR §20.2110. These records are used to document the radiation exposures of individuals and are available as prescribed by the Privacy Act of 1974. These records are also used for (1) evaluation of the effectiveness of the radiological protection program, (2) demonstration of compliance with regulations and requirements, and (3) personnel records. These dose records are sufficient to evaluate compliance with applicable dose limits, and monitoring and reporting requirements. Occupational exposures in excess of regulatory limits are reported to the NRC as required by regulations.

As a minimum, exposure reports are provided to individuals under the following conditions:

- Upon request from an individual terminating employment, records of exposure are provided to that individual when the data become available.
- If requested, a written estimate of radiation dose, based on available information at the time of termination, is provided.
- Annual radiation dose reports are provided to individuals monitored during the year.
- If requested, detailed exposure information is provided.
- Reports are provided to individuals when required to report to the NRC pursuant to occurrence reporting and processing, or planned special exposures.

9.2.14 Additional Program Commitments

Occupational exposures in excess of prescribed limits are referred to the corrective action program.

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Tables

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Table 9.1-1. MFFF Radiation Zoning Criteria

Zone	Design Basis Maximum Area Radiation Dose Rate (mrem/hr)
Z1 - High access area	<0.05
Z2 - Intermediate access area	<0.25
Z3 - Low access area	<5.0
Z4 - Very low access area	<100
Z5 - Restricted access area	>100

Table 9.1-2. Summary of Dose Limits and Goals

	10CFR20 Limits	Administrative Goals
General Employee: Whole Body (internal CEDE + external EDE) (TEDE)	5 rem/yr	0.5 rem/yr
General Employee: Lens of Eye 15 rem (LDE)	15 rem/yr	10 rem/yr
General Employee: Skin and extremities (external shallow dose) (SDE)	50 rem/yr	10 rem/yr
General Employee: Any organ or tissue 50 rem (other than lens of eye) and skin	50 rem/yr	5 rem/yr
General Employee: Soluble uranium intake	10 mg/week	1 mg/week
Declared Pregnant Worker: Embryo/Fetus (TEDE)	0.5 rem/gestation period	0.5 rem/gestation period

Notes:

1. The annual limit of dose to "any organ or tissue" is based on the committed dose equivalent to that organ or tissue resulting from internally deposited radionuclides over a 50-year period after intake plus any deep dose equivalent to that organ from external exposures during the year.
2. Exposures due to background radiation, as a patient undergoing therapeutic and diagnostic medical procedures, and participation as a subject in medical research programs shall not be included in either personnel radiation dose records or assessment of dose against the limits in this table.
3. Whole body dose (TEDE) = effective dose equivalent from external exposures + committed effective dose equivalent from internal exposures.
4. Lens of the eye dose equivalent = dose equivalent from external exposure determined at a tissue depth of 0.3 cm.
5. Shallow dose equivalent = dose equivalent from external exposure determined at a tissue depth of 0.007 cm
6. The soluble uranium intake limit is in consideration of the chemical toxicity.
7. Minors (below age 18) are allowed to enter radiation areas only with RPM permission. Dose limits for minors will be in accordance with 10 CFR §20.1207.

Table 9.2-1. Summary of Contamination Values

Radionuclide[1]	Removable[2] (dpm/100 cm^2)	Total[3] (Average) (dpm/100 cm^2)
U-natural, ^{235}U, ^{238}U, and associated decay products	1,000 alpha	5,000 alpha
Transuranics (including Pu isotopes), ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac	20	100
Th-nat, ^{232}Th, ^{223}Ra, ^{224}Ra, ^{232}U	200	1000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission). Includes mixed fission products containing ^{90}Sr [4,5]	1,000 beta-gamma	5,000 beta-gamma
Tritium and tritiated compounds	10,000	N/A

Notes:

1. Except as noted in Footnote 5 below, the values in this table apply to radioactive contamination deposited on, but not incorporated into the interior of, the contaminated item. Where contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for the alpha- and beta-gamma-emitting nuclides apply independently.
2. The amount of removable radioactive material per 100 cm^2 of surface area shall be determined by swiping the area with dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note: The use of dry material may not be appropriate for tritium.) For objects with a surface area less than 100 cm^2, the entire surface shall be swiped, and the activity per unit area shall be based on the actual surface area. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.
3. The levels may be averaged over 1 square meter provided the maximum activity in an area of 100 cm^2 is less than three times the values in the table.
4. This category of radionuclides includes mixed fission products, including the ^{90}Sr, which is present in them. It does not apply to ^{90}Sr that has been separated from the other fission products or mixtures where the ^{90}Sr has been enriched.
5. These values shall be applied to total $^{90}Sr/^{90}Y$ activity resulting from the presence of ^{90}Sr in mixed fission products.

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10. ENVIRONMENTAL PROTECTION

The components of the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) Environmental Protection Program include:

- Radiation safety controls to assess the level of radioactive releases to the environment, maintain public dose as low as is reasonably achievable (ALARA), minimize facility and environmental contamination, facilitate eventual deactivation, and minimize waste generation
- Effluent monitoring to measure and monitor radioactive effluents released from the facility during normal and off-normal operations
- Environmental surveillances to monitor environmental impact from operations during normal and off-normal operations.

10.1 RADIATION SAFETY

This section describes the methods used to maintain dose outside the Restricted Area Boundary (RAB) ALARA, in accordance with Title 10 of the Code of Federal Regulations (CFR) §20.1101. Facility radiation safety is described in Chapter 9.

10.1.1 ALARA Goals for Effluent Control

Calculations performed in accordance with 10 CFR §20.1302(b)(1) using the guidance provided in Regulatory Guide 4.20, Section 2.2, demonstrate that the Total Effective Dose Equivalent (TEDE) to an individual outside of the RAB likely to receive the highest dose from licensed operation does not exceed 100 mrem/yr, as required in 10 CFR §20.1301(a)(1).

The ALARA goal for TEDE to the individual outside of the RAB likely to receive the highest dose from air emissions of radioactive material to the environment during normal operations, excluding ^{222}Rn and its daughters, is less than 10 mrem/yr, which is 10% of dose stated in 10 CFR §20.1301(a)(1) and is consistent with 10 CFR §20.1101(d). Reports are made in accordance with 10 CFR §20.2203 if the 10 mrem/yr dose constraint is exceeded during off-normal operations.

No radioactive liquid effluents are predicted or anticipated for normal operations.

Dose estimates are monitored and compared to ALARA goals. Duke Cogema Stone & Webster (DCS) management is apprised of data in accordance with the ALARA program.

10.1.2 Effluent Controls

Effluent controls, consisting of airborne, liquid, and solid waste management, reduce exposure to individuals outside of the RAB and minimize releases to the environment.

10.1.2.1 Control of Airborne Emissions

Airborne emissions are controlled by the heating, ventilation, and air conditioning (HVAC) system and the Offgas Treatment (KWG) unit ventilation system that removes radionuclides, nitrous fumes, and other hazardous materials from the Aqueous Polishing (AP) process systems offgas. Airborne waste from MFFF processes is routed through the HVAC system. The HVAC system is designed to handle the expected volume of potentially radioactive waste, compartmentalize the airborne waste to reduce the potential for cross-contamination, safely handle the chemical characteristics of the airborne waste, achieve an acceptable decontamination factor for each radionuclide, and be capable of safe shutdown consistent with the operating status. Several design features of the HVAC system support specific areas of the facility, such as the MOX Processing (MP) and AP Areas. These features include items relied on for safety (IROFS) to provide for confinement of radioactive materials. Ventilation exhaust from contaminated gloveboxes is passed through multiple banks of filters, including high-efficiency particulate air (HEPA) filters. The arrangement and control of IROFS ensure that contaminated exhaust does not bypass confinement controls.

Airborne emissions are monitored and controlled to maintain dose outside the RAB ALARA.

Trending results from effluent monitors, samplers, and other MFFF airborne monitoring equipment provide early indication of increased radioactivity in ventilation exhaust. Procedures identify evaluations and actions to be taken when the concentrations of airborne radioactivity exceed prescribed limits.

10.1.2.2 Liquid Waste Management

The AP process uses recycling to the maximum extent practical to minimize liquid waste. Liquid waste management is integrated into the fluid transport systems. The fluid transport systems are designed to handle the maximum expected volume of potentially radioactive waste, compartmentalize the liquid waste to reduce the potential for cross-contamination, safely handle the chemical characteristics of the liquid waste, and be capable of safe shutdown consistent with the operating status. Liquid radioactive waste is transferred to U.S. Department of Energy (DOE) facilities at the Savannah River Site (SRS) in a manner consistent with the SRS Waste Acceptance Criteria (WAC) for appropriate storage and disposition. SRS will take possession of the waste prior to reaching the RAB and is responsible for the safe movement of the waste.

Liquid radioactive wastes and liquid nonradioactive wastes are collected and managed in separate systems that have no opportunity for interconnection. Radioactive process fluids are maintained within at least two levels of confinement. Radioactive process fluids are transferred using means such as gravity flow, airlifts, air jets, and steam jets, when practical. Drains within the radiation control area are routed to the liquid waste system. Liquid radioactive wastes are collected in the aqueous liquid waste system or the solvent liquid waste system, and are sent to SRS for disposition. Outside the radiation control area, liquid nonradioactive wastes are collected and sent to SRS for disposition. Systems containing nonradioactive hazardous fluids are of fully-welded construction and are accessible for inspection.

Prior to transfer to SRS, liquid wastes from storage tanks are sampled and analyzed to ensure that waste transfers meet the SRS WAC.

10.1.2.3 Solid Waste Management

Solid wastes are transferred to SRS for disposition. MFFF quantifies the activity in radioactive solid waste containers to ensure that waste shipments meet the SRS WAC.

Hazardous solid waste is waste that is, or contains, a listed hazardous waste, or that exhibits one of the four U.S. Environmental Protection Agency (EPA) hazardous waste characteristics (i.e., ignitability, corrosivity, reactivity, and toxicity). Hazardous waste includes nonradioactive laboratory wastes. Mixed low-level waste is waste that is radioactive and contains chemical components regulated by EPA as hazardous waste, while mixed transuranic waste is waste that meets the criteria for transuranic waste and contains chemical components regulated by EPA as hazardous waste.

Mixed low-level waste and mixed transuranic waste are packaged and transferred to SRS in a manner consistent with the SRS WAC for processing and disposal within 90 days of generation. SRS will take possession of the waste prior to reaching the RAB and is responsible for the safe transfer of the waste. To the extent practical, commingling of waste from streams requiring different treatment technologies is prevented. Containers of hazardous waste known or suspected to be contaminated with radioactive material are uniquely labeled and tracked through storage and shipping.

10.1.3 ALARA Reviews and Reports to Management

Reports summarizing the ALARA program are provided to DCS management. They include trending information, so that analytical results can be compared to ALARA goals. Emission and effluent radionuclide concentrations and radionuclides transferred to SRS as liquid and solid waste are included in trend analyses. Abnormal increases in the trend of analytical results are reported to DCS senior management as soon as practical. To ensure that releases are maintained ALARA, DCS management is informed quarterly of the trends measured against ALARA goals. ALARA goals are reevaluated annually, and new goals are established for the upcoming year as appropriate. Recommendations are made to DCS senior management, as needed, for changes in facilities and procedures to achieve ALARA goals. Effluent controls are reviewed annually as part of the radiological protection program annual review to ensure public doses are ALARA.

If an adverse trend is noted, an evaluation is made to determine if a detrimental effect is evident in the environment or the surrounding biota. The evaluation considers the information provided by the environmental surveillance network. Based on facility operating history and the data obtained from environmental surveillances during operations, the sampling and/or analysis programs are adjusted to optimize reliability.

10.1.4 Waste Minimization and Pollution Prevention

Waste management is guided by the principles of ALARA, waste minimization, and pollution prevention. Waste minimization is accomplished through a design that reduces the potential for

waste generation, and an operations philosophy that minimizes the introduction of excess materials that can become contaminated.

The MFFF process implements recycling and reuse for waste minimization. For example, the recycling process minimizes the quantity of plutonium in the final waste by using systems that return (recycle) radioactive material to previous steps of the main process. Liquid waste is minimized in the AP process by use of recycling to the maximum extent practical. Nitric acid is recovered by evaporation from the process and partly reused as reagent feedstock for the plutonium dissolution subprocess. Distillates from the evaporation process are collected and partly reused in the process. Spent solvent from the plutonium separation step is regenerated by washing with sodium carbonate, sodium hydroxide, and nitric acid to remove degradation products from organic compounds, including trace amounts of plutonium and uranium.

Solid waste is minimized by reuse of solid scrap material from fuel fabrication. Many other system design features perform contamination control, confinement, and associated waste minimization functions. The process design reduces the distribution and retention of radioactive materials throughout plant systems by using vacuum systems in the gloveboxes. Airborne dust is collected in dust pots in dedusting systems installed in the gloveboxes, and the material is recycled. These design features control contamination to ensure that secondary waste production is minimized during plant operation.

Waste minimization procedures will require separation and segregation of solid and liquid wastes and the removal of packing and shipping materials prior to entry into contaminated areas. Waste minimization reduces worker and public exposure to radiation and to radioactive and hazardous materials.

Waste minimization programmatic documentation includes a statement of senior management support and identification of management, employees, and organizational responsibilities for waste minimization. Waste minimization includes periodic characterization of waste and assessment of waste management practices to identify opportunities to enhance waste minimization. Goals for waste minimization are established based on operational data. To ensure that waste generation is minimized, management is informed quarterly of the trends measured against waste minimization goals. The goals are reevaluated annually, and new goals are established for the upcoming year as appropriate. Recommendations are made to DCS senior management, as needed, for changes in facilities and procedures to achieve waste minimization goals.

The MFFF process implements recycling and reuse for waste minimization. For example, the recycling process minimizes the quantity of plutonium in the final waste by using systems that return (recycle) radioactive material to previous steps of the main process. Many other system design features perform contamination control, confinement, and associated waste minimization functions. These design features control contamination to ensure that secondary waste production is minimized during plant operation.

10.2 EFFLUENT MONITORING

10.2.1 Air Emissions

The maximum annual concentrations of radioactive airborne effluents are expected to be much less than the values in 10 CFR Part 20, Appendix B, Table 2. Estimated isotopic distribution of emissions is shown in Table 10.2-1. DCS does not plan to request U.S. Nuclear Regulatory Commission (NRC) approval to adjust effluent concentrations shown in 10 CFR 20 Appendix B; therefore, physical and chemical properties are not described here.

10.2.1.1 Discharge Locations

Exhaust from MFFF processes is filtered and discharged to the environment via a stack located on top of the MOX Fuel Fabrication Building.

10.2.1.2 Sample Collection, Frequency, and Analytical Methods

Based on Regulatory Guide 4.16, Revision 1, a representative sample of the particulate effluent from the stack is continuously collected during operations. The representative sample is collected on a filter for determination of quantities and average concentrations of principal radionuclides that are released. The analytical methodologies used to characterize airborne emissions are listed in Table 10.2-2.

To investigate abnormal stack releases and/or anomalies, sample connections are installed at key locations in process area ventilation ducts. The placement and use of sample connections are based on minimizing the risk to facility workers, site personnel, and members of the public. The potential for leakage from process systems, equipment, and confinement is also considered. The evaluation focuses on the equipment and spaces with the highest potential for leakage of airborne contaminants. During MFFF operations, elevated readings from continuous air monitors (CAMs) and/or fixed air samplers are used to identify the need to perform maintenance, or to take other action to reduce effluent releases. To quantify the contribution from each source, CAMs sample the discharged air from the MP and AP process areas and, as appropriate, other areas that are not used for processing special nuclear material.

Analytical quality control methodology is described in the appropriate laboratory manual and is subject to Quality Assurance controls. Analytical procedures are consistent with national or international consensus standards or have equivalent or superior performance to such methods. Analytical instrumentation is standardized and calibrated in accordance with the manufacturer's recommendations. Calibration standards are traceable to the National Institute of Standards and Technology.

10.2.2 Liquid Effluents

Liquid radioactive waste is collected by the liquid aqueous liquid waste system or the solvent liquid waste system and transferred to SRS for disposition. The MFFF does not discharge radioactive liquid to the environment during normal and off-normal operations. The expected nonradioactive liquid release is from stormwater and water from HVAC noncontact condensate that is released to the storm drains.

10.2.2.1 Discharge Locations

The MFFF does not discharge process effluents. The National Pollutant Discharge Elimination System (NPDES) discharge for stormwater runoff is designated in South Carolina Department of Health and Environmental Control (SCDHEC) NPDES General Permit and related documents (e.g., Storm Water Pollution Prevention Plan).

10.2.2.2 Leak Detection Systems for Ponds, Lagoons, and Tanks

The MFFF does not use wastewater treatment ponds, lagoons, or other process water holding ponds. The only pond on the MFFF site is the stormwater retention basin, which does not receive process liquid discharges from the MFFF. Tanks used for storage of radioactive material are located inside MFFF buildings and are equipped with drip pans and leak detection.

10.2.3 Recording/Reporting Procedures

Data from the sampling and monitoring are reviewed on a regular basis. Radionuclide activities are trended over a period of time at each sampling location for each media to determine the effects of facility operation. If an increasing trend is noted, an evaluation is made to determine if a detrimental effect has been seen in the environment or in the surrounding biota. The appearance of an increasing activity trend in itself is not cause for action. Based upon the operating history of the facility and operational data, sampling and/or analysis programs are adjusted as necessary.

DCS submits a summary of the effluent monitoring to the NRC semiannually.

10.3 ENVIRONMENTAL SURVEILLANCES

Environmental surveillances assess the environmental impact of licensed activities, which include preoperational and operational environmental monitoring activities. Radionuclide analyses are performed more frequently if there is an unexplained increase of gross radioactivity in airborne emissions, or when a process change or other circumstance might cause a variation in radionuclide concentration.

Radiological impacts to the environment from airborne emissions during operation of the MFFF are expected to be minimal. Because the MFFF does not discharge radioactive liquids directly to the environment, the environmental surveillances focus on the environmental media impacted by the airborne pathway for the anticipated types and quantities of radionuclides released from the facility.

10.3.1 Pathway Analysis Methods to Estimate Public Dose

As noted above, the MFFF does not release radioactive effluents to the aquatic environment. Consequently, the pathways for radionuclides to reach the public or environment are associated with airborne emissions. The dominant pathway for MFFF releases to reach human consumption is inhalation of airborne emissions. Deposition of airborne particulates on crops and ingestion of the contaminated agricultural products is a secondary pathway for radionuclides to reach the environment and human consumption. However, because the MFFF is located on a DOE

reservation, there are no consumable crops within 5 miles of the MFFF. A tertiary pathway is deposition of airborne particulates to water, or contaminated runoff to nearby streams and ingestion of the water or fish. Again, since the MFFF is on a DOE reservation, the importance of this pathway is significantly reduced. The analysis of public dose considers inhalation uptake, external exposure to the airborne plume, ingestion of terrestrial foods and animal products, and inadvertent soil ingestion.

10.3.2 Environmental Media to be Monitored and Sample Locations

The environmental surveillances track each pathway for the release of MFFF radioactivity to the environment. Environmental surveillances include monitoring of airborne particulates and deposition of particulates on surrogates for crops, such as grass and soil, and nearby streams. Environmental surveillances evaluate the effects of both short-term and long-term deposition.

Locations and sampling frequencies during operations phase monitoring are adjusted, based on the results of the preoperational surveillances or operational emissions monitoring results.

10.3.3 Preoperational Surveillances

The DOE has monitored the SRS site for many years. MFFF preoperational environmental surveillances provide a link between the long-term DOE data and the MFFF operational environmental surveillances. Preoperational environmental surveillances begin approximately two years prior to production of commercial fuel. The objectives of the preoperational environmental surveillances are:

- Establish a baseline of existing radiological and biological conditions at and nearby the MFFF site
- Evaluate procedures, equipment, and techniques used in the collection and analysis of environmental data, and train personnel in their use
- Determine the presence of contaminants that could be a safety concern for personnel.

Preoperational surveillances establish a baseline for operational environmental surveillance for radioactivity levels of environmental media (e.g., air, soil, sediments, and vegetation), as appropriate, with analyses for uranium, plutonium, and other radionuclides of interest.

10.3.3.1 Air Sampling and Analysis

Preoperational air quality sampling establishes the baseline to be used during the operational monitoring period. The airborne monitoring provides a comprehensive baseline of radiological conditions related to airborne emissions in the environs of the MFFF. Three air sampling locations monitor exposure at the RAB to the east, southwest, and northwest of the MFFF building. The airborne radiological monitoring program, including the sampling locations, is outlined in Table 10.3-1.

Three additional air sampling locations, corresponding to existing SRS monitoring points, monitor exposure at the SRS boundary and are identified in Table 10.3-1. These sampling

locations assist in estimating dose to the offsite public, conservatively assuming a member of the offsite public spends all their time at the SRS boundary. Air quality monitoring points are subject to emissions from not only the MFFF, but also from other SRS operations. Environmental observations are evaluated in conjunction with MFFF emissions data and atmospheric transport and dispersion modeling projections. Preoperational monitoring is used to establish the baseline for both isotopic composition and concentrations, which are then compared to observations during MFFF operations.

Analytical methods and lower limit of detection (LLD) for analyses of airborne isotopes are listed in Table 10.3-2. For rainwater samples, the rainwater is evaporated and then the dry material is counted. Sufficient volumes of samples are collected to ensure the attainment of LLD thresholds in the analysis. Samples are processed and packaged in a manner to ensure the integrity of each sample.

10.3.3.2 Water Sampling and Analysis

The MFFF does not discharge process water to the environment. Deposition rates of airborne contaminants to water bodies are estimated based on airborne environmental surveillances and confirmed by water and sediment sampling.

10.3.3.3 Terrestrial Sampling and Analysis

Preoperational terrestrial radiological monitoring is outlined in Table 10.3-3. It provides a comprehensive baseline of radiological conditions related to airborne emissions in the environs of the MFFF.

Soil samples are collected, using hand augers or equivalent devices, from uncultivated and undisturbed areas. Grassy vegetation is collected at locations adjacent to the soil sample by hand picking vegetation.

Analytical methods and LLDs for terrestrial environmental samples are listed in Table 10.3-4. Sufficient volumes of samples are collected when available, using accurate sample collection methods to ensure the attainment of LLDs in the analyses. Samples are processed and packaged in a manner to ensure the integrity of each sample.

10.3.4 Operational Monitoring

Locations and sampling frequency during the operational monitoring period may be altered based on the results of the preoperational monitoring or operational emissions monitoring results. The frequency of the monitoring described in this section may be reduced when a consistent radionuclide composition in effluents is established.

10.3.4.1 Air Sampling and Analysis

Operational air quality sampling is based on the results of preoperational and emission monitoring. The operational airborne radiological monitoring is outlined in Table 10.3-5.

Analytical methods and LLDs are listed in Table 10.3-6. For rainwater samples, the rainwater is evaporated and then the dry material is counted. Sufficient volumes of samples are collected to ensure the attainment of LLDs in the analyses. Samples are processed and packaged in a manner to ensure the integrity of each sample.

10.3.4.2 Water Sampling and Analysis

The MFFF does not discharge process water to the environment. Deposition rates of airborne contaminants into water bodies are estimated based on airborne environmental surveillances and confirmed by water and sediment sampling.

10.3.4.3 Terrestrial Sampling and Analysis

Operational terrestrial radiological monitoring is outlined in Table 10.3-7. It provides an evaluation of radiological impacts related to deposition of airborne emissions in the environs of the MFFF. Terrestrial samples are collected in the vicinity of the air quality monitors to allow association of the particulate and rainwater analyses with vegetation analyses.

Soil samples are collected, using hand augers or equivalent devices, from uncultivated and undisturbed areas. Grassy vegetation is collected at locations adjacent to the soil sample by hand picking vegetation.

Analytical methods and LLDs for analyses of terrestrial environmental samples are listed in Table 10.3-8. Sufficient volumes of samples are collected when available, using accurate sample collection methods to ensure the attainment of LLDs in the analyses. Samples are processed and packaged in a manner to ensure the integrity of each sample.

10.3.5 Action Levels and Actions

Title 10 CFR §20.1301 establishes regulatory limits for dose to the public. To ensure that the regulatory limits are not exceeded, DCS has established administrative limits and action levels as shown in Table 10.3-9. If an action level is exceeded for sampling, an investigation is performed to determine the source of the elevated activity. Emission data are trended as an analytical tool.

10.3.6 Recording/Reporting Procedures

Data from the sampling are reviewed on a regular basis.

Radionuclide activities are trended at each sampling location for each media to determine the effects of facility operation. If an increasing trend is noted, an evaluation is performed to determine if a detrimental effect has been seen in the environment or in the surrounding population.

Based upon the operating history of the facility and operational data, sampling and/or analysis programs are adjusted as necessary.

Results of the environmental surveillances are summarized annually.

Reports and notifications of theft or loss of licensed material are submitted as required. Reports and notifications of concentrations of principal radionuclides released are provided, and include the minimum detectable concentration for the analysis. Reports and notifications of exposure incidents above acceptable levels are submitted as required.

10.3.7 Monitoring Procedures, Analytical Methods, and Instrumentation

Analytical quality control is described in laboratory procedures and is consistent with the MOX Project Quality Assurance Plan. Analytical procedures are consistent with national or international consensus standards or have equivalent or superior performance to such methods. Analytical instrumentation is standardized and calibrated in accordance with the manufacturer's recommendations. Calibration standards are traceable to the National Institute of Standards and Technology.

10.4 ENVIRONMENTAL PERMITS

Table 10.4-1 lists the environmental permits and plans that are required prior to operation of the MFFF.

Tables

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Table 10.2-1. Estimated Radiological Releases from the MFFF during Normal Operations

Isotope	Airborne Radiological Releases (μCi/yr)
^{3}H	3.0E+6 [1]
^{237}Np	7.2E-04
^{236}Pu	1.3E-08
^{238}Pu	8.5
^{239}Pu	91
^{240}Pu	23
^{241}Pu	101
^{242}Pu	6.1E-03
^{241}Am	48
^{234}U	5.1E-03
^{235}U	2.1E-04
^{238}U	0.012

Note 1: Value is based on revision of feedstock specifications

Table 10.2-2. Analytical Methods for Characterization of Airborne Emissions

Parameter	Analytical Method	Lower Limit of Detection[1] (µCi/ml)
Gross alpha	Gas-flow proportional counter	1.0E-15 [2]
Gross beta	Gas-flow proportional counter	1.0E-15 [2]
^{3}H	Liquid scintillation	5.0E-09
^{237}Np	Alpha spectrometer	5.0E-16
^{241}Am	Alpha spectrometer	1.0E-15
^{238}Pu	Alpha spectrometer	1.0E-15
^{239}Pu, ^{240}Pu	Alpha spectrometer	1.0E-15
^{235}U	Alpha spectrometer	3.0E-15
^{238}U	Alpha spectrometer	3.0E-15

Note 1: Lower limit of detection values are 5% of the values in 10CFR20, Appendix B, Table 2
Note 2: It is estimated that this LLD can be met based on design basis, which is susceptible to change.

Table 10.3-1. Preoperational Airborne Radiological Monitoring

Location	Description of Monitor Location	Frequency	Collection Methodology	Analyses
A-01	SW corner of MFFF site about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-02	East of MFFF stack about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-03	NW of MFFF about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-05	400-D, SRS boundary in the principal wind direction	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np

Table 10.3-1. Preoperational Airborne Radiological Monitoring (continued)

Location	Description of Monitor Location	Frequency	Collection Methodology	Analyses
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-06	West Jackson - SRS boundary at centerline to nearest residence	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-07	Aiken Barricade - SRS boundary in the 2nd principal wind direction	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H

Table 10.3-2. Preoperational Methodology and Lower Limits of Detection for Airborne Environmental Samples

Analyte	Method	Lower Limit of Detection[1] (µCi/ml)
Particulate		
Gross alpha	Gas-flow proportional counter	1.0E-13 [2]
Gross beta	Gas-flow proportional counter	5.0E-13 [2]
^{3}H	Liquid scintillation	5.0E-09
^{237}Np	Alpha spectrometer	5.0E-16
^{241}Am	Alpha spectrometer	1.0E-15
^{238}Pu	Alpha spectrometer	1.0E-15
^{239}Pu, ^{240}Pu	Alpha spectrometer	1.0E-15
^{235}U	Alpha spectrometer	3.0E-15
^{238}U	Alpha spectrometer	3.0E-15
Rainwater		
Gross alpha	Gas-flow proportional counter	9.0E-09
Gross beta	Gas-flow proportional counter	1.5E-08
^{3}H	Liquid scintillation	5.0E-05
^{237}Np	Alpha spectrometer	1.0E-09
^{241}Am	Alpha spectrometer	1.0E-09
^{238}Pu	Alpha spectrometer	1.0E-09
^{239}Pu, ^{240}Pu	Alpha spectrometer	1.0E-09
^{235}U	Alpha spectrometer	1.5E-08
^{238}U	Alpha spectrometer	1.5E-08

Note 1: Lower limit of detection values are 5% of the values in 10CFR20, Appendix B, Table 2
Note 2: Lower limit of detection value is based on potential contractor minimum detectable activity.

Table 10.3-3. Preoperational Terrestrial Radiological Monitoring

Location	Description of Monitor Location	Media[1]	Frequency	Analyses[2]
VS-01 (A-01)	SW corner of MFFF site about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-02 (A-02)	East of MFFF stack about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-03 (A-03)	NW of MFFF about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-05 (A-05)	400-D, SRS boundary in the principal wind direction	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-06 (A-06)	West Jackson - SRS boundary at centerline to nearest residence	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-07 (A-07)	Aiken Barricade - SRS boundary in the 2nd principal wind direction	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H

Note 1: V = Vegetation; S = Soil
Note 2: For terrestrial radiological monitoring ^{3}H is only analyzed for in vegetation.

Table 10.3-4. Preoperational Methodology and Lower Limits of Detection for Terrestrial Environmental Samples

Analyte	Method	Lower Limit of Detection[1] (pCi/g)
Soil		
^{237}Np	Alpha spectrometer	6.0 E-03
^{241}Am	Alpha spectrometer	8.0E-03
^{238}Pu	Alpha spectrometer	6.0 E-03
^{239}Pu, ^{240}Pu	Alpha spectrometer	6.0 E-03
^{235}U	Alpha spectrometer	8.0E-03
^{238}U	Alpha spectrometer	8.0E-03
Vegetation		
^{3}H	Liquid scintillation	5.0E-03
^{237}Np	Alpha spectrometer	4.0E-03
^{241}Am	Alpha spectrometer	4.0E-03
^{238}Pu	Alpha spectrometer	4.0E-03
^{239}Pu, ^{240}Pu	Alpha spectrometer	4.0E-03
^{235}U	Alpha spectrometer	2.0E-03
^{238}U	Alpha spectrometer	2.0E-03

Note 1: Lower limit of detection values are based on potential contractor minimum detectable activity.

Table 10.3-5. Operational Airborne Radiological Monitoring

Location	Description of Monitor Location	Frequency	Collection Methodology	Analyses
A-01	SW corner of MFFF site about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-02	East of MFFF stack about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-03	NW of MFFF about 700 ft from BMF	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H

Table 10.3-5. Operational Airborne Radiological Monitoring (continued)

Location	Description of Monitor Location	Frequency	Collection Methodology	Analyses
A-05	400-D, SRS boundary in the principal wind direction	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-06	West Jackson - SRS boundary at centerline to nearest residence	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H
A-07	Aiken Barricade - SRS boundary in the 2nd principal wind direction	Air filters collected biweekly	Air particulate samplers using glass fiber filters	Gross alpha/beta
		Air filters monthly composite	Air particulate samplers using glass fiber filters	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np
		Monthly	Rainwater collected and passed through ion exchange columns in the field	Gross alpha/beta, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
		Biweekly	Silica Gel	^{3}H

Table 10.3-6. Operational Methodology and Lower Limits of Detection for Airborne Environmental Samples

Analyte	Method	Lower Limit of Detection[1] (µCi/ml)
Particulate		
Gross alpha	Gas-flow proportional counter	1.0E-13[2]
Gross beta	Gas-flow proportional counter	5.0E-13[2]
^{3}H	Liquid scintillation	5.0E-09
^{237}Np	Alpha spectrometer	5.0E-16
^{241}Am	Alpha spectrometer	1.0E-15
^{238}Pu	Alpha spectrometer	1.0E-15
^{239}Pu, ^{240}Pu	Alpha spectrometer	1.0E-15
^{235}U	Alpha spectrometer	3.0E-15
^{238}U	Alpha spectrometer	3.0E-15
Rainwater		
Gross alpha	Gas-flow proportional counter	9.0E-09
Gross beta	Gas-flow proportional counter	1.5E-08
^{3}H	Liquid scintillation	5.0E-05
^{237}Np	Alpha spectrometer	1.0E-09
^{241}Am	Alpha spectrometer	1.0E-09
^{238}Pu	Alpha spectrometer	1.0E-09
^{239}Pu, ^{240}Pu	Alpha spectrometer	1.0E-09
^{235}U	Alpha spectrometer	1.5E-08
^{238}U	Alpha spectrometer	1.5E-08

Note 1: Lower limit of detection values are 5% of the values in 10CFR20, Appendix B, Table 2
Note 2: Lower limit of detection value is based on potential contractor minimum detectable activity.

Table 10.3-7. Operational Terrestrial Radiological Monitoring

Location	Description of Monitor Location	Media[1]	Frequency	Analyses[2]
VS-01 (A-01)	SW corner of MFFF site about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-02 (A-02)	East of MFFF stack about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-03 (A-03)	NW of MFFF about 700 ft from BMF	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-05 (A-05)	400-D, SRS boundary in the principal wind direction	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-06 (A-06)	West Jackson - SRS boundary at centerline to nearest residence	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{23}5U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H
VS-07 (A-07)	Aiken Barricade - SRS boundary in the 2nd principal wind direction	V, S	Annual	^{238}Pu, ^{239}Pu, ^{240}Pu, ^{235}U, ^{238}U, ^{241}Am, ^{237}Np, ^{3}H

Note 1: V = Vegetation; S = Soil.
Note 2: For terrestrial radiological monitoring ^{3}H is only analyzed for in vegetation.

Table 10.3-8. Operational Methodology and Lower Limits of Detection for Terrestrial Environmental Samples

Analyte	Method	Lower Limit of Detection[1] (pCi/g)
Soil		
^{237}Np	Alpha spectrometer	6.0E-03
^{241}Am	Alpha spectrometer	8.0E-03
^{238}Pu	Alpha spectrometer	6.0E-03
^{239}Pu, ^{240}Pu	Alpha spectrometer	6.0E-03
^{235}U	Alpha spectrometer	8.0E-03
^{238}U	Alpha spectrometer	8.0E-03
Vegetation		
^{3}H	Liquid scintillation	5.0E-03
^{237}Np	Alpha spectrometer	4.0E-03
^{241}Am	Alpha spectrometer	4.0E-03
^{238}Pu	Alpha spectrometer	4.0E-03
^{239}Pu, ^{240}Pu	Alpha spectrometer	4.0E-03
^{235}U	Alpha spectrometer	2.0E-03
^{238}U	Alpha spectrometer	2.0E-03

Note 1: Lower limit of detection is based on potential contractor minimum detectable activity.

Table 10.3-9. Administrative Limits and Action Levels for Air Emissions

Parameter	Action Level[1] (µCi/ml)	Action
Alpha activity	3.2 E-14	Recount sample(s), including full isotope spectroscopy and compare to individual isotope regulatory limits
Alpha activity	6.4 E-14	Evaluate operations for possible source of positive activity
Alpha activity	3.2 E-13	Releases are potentially above allowable 10 CFR Part 20, Appendix B, Table 2 effluent limits. Initiate orderly shutdown of associated processes for repair or correction.

Note 1: Calculated values at the MFFF BMF stack.

Table 10.4-1. Status of Federal, State and Local Licenses, Permits and Approvals

Requirement	Status	Comments
Federal Laws and Enabling Regulations		
Negative declaration on cultural resources from the State Historic Preservation Officer (SHPO) 43 CFR Part 7; 36 CFR Parts 60, 61, 63, 65, 67, 68	Completed	SHPO approved mitigation plan on 11 April 2001. Mitigation completed August 2002.
Negative declaration on endangered species from the U.S. Fish and Wildlife Services (USFWS) 50 CFR Parts 13, 17, 222, 226, 227, 402, 424, 450-453	Completed	USFWS issued negative declaration on 20 June 2001.
Negative declaration on prime or unique farmlands from U.S. Natural Resources Conservation Service (USNRCS) 7 CFR Part 658	Not required	USNRCS does not identify SRS as prime farmlands because the land is not available for agricultural production.
Negative declaration on 404 Permit from U.S. Army Corps of Engineers (COE)	Not required	No jurisdictional wetlands exist on MFFF site.
Floodplain Assessment	Completed	Floodplain Assessment incorporated into the design basis.
Construction Environmental Plans and Permits		
Construction Emissions Control Plan (CECP) 40 CFR 60 South Carolina Regulation 61.62-6	Completed	CECP was completed and does not need to be approved by SCDHEC.
Bureau of Air Quality (BAQ) Construction Permit 40 CFR 60 South Carolina Regulation 61.62-5	Completed	BAQ Construction Permit for BMF Stack, Diesel Generators, and Diesel Fuel Tanks has been received from SCDHEC in 2006. BAQ Construction Permit for Concrete Batch Plant will be drafted after vendor selection in Spring 2007.

Table 10.4-1. Status of Federal, State and Local Licenses, Permits and Approvals (continued)

Requirement	Status	Comments
BAQ National Emission Standard for Hazardous Air Pollutants (NESHAP) Construction Permit 40 CFR 61 Subpart H 10 CFR 20 South Carolina Regulation 61.62-5	Completed	Alternative Calculation methodology approved by EPA Region IV and SCDHEC in April 2002. Exemption from NESHAP Construction Permit granted.
Bureau of Water Quality (BWQ) Construction NPDES General Permit 40 CFR 122 South Carolina Regulation 61-9 South Carolina Regulation 61-68 South Carolina Regulation 72-300 through 72-316 (GR)	Completed	Access to BWQ General Permit granted in May 2005 upon acceptance of Notice of Intent (NOI) and SWPPP by SCDHEC.
BWQ Sanitary Wastewater Construction Permit 40 CFR 122 South Carolina Regulation 61-9 South Carolina Regulation 61-67	In progress	Permit from tie-in to interface point has been received. Permit from interface point to MFFF has been drafted and will be submitted to SCDHEC in 2007.
BWQ Construction Storm Water Pollution Prevention Plan (SWPPP) 40 CFR 122 South Carolina Regulation 61-9 South Carolina Regulation 61-68 South Carolina Regulation 72-300 through 72-316 (GR)	Completed	Accepted by SCDHEC with NOI in May 2005. BWQ SWPP for Concrete Batch Plant will be drafted after vendor selection in Fall 2006.
BWQ Domestic Water Distribution Construction Permit 40 CFR 141 South Carolina Regulation 61-58 South Carolina Regulation 61-71 South Carolina Regulation 61-101	In progress	Permit from tie-in to interface point has been received. Permit from interface point to MFFF has been drafted and will be submitted to SCDHEC in 2007.
Bureau of Land and Waste Management (BLWM) Underground Storage Tank (UST) Installation Permit 40 CFR 112 40 CFR 280 South Carolina Regulation 61-92	In progress	BLWM UST Permit has been drafted and will be submitted to SCDHEC in 2007

Table 10.4-1. Status of Federal, State and Local Licenses, Permits and Approvals (continued)

Requirement	Status	Comments
Waste Minimization and Pollution Prevention Plan 40 CFR 261 40 CFR 262 40 CFR 264 40 CFR 268 South Carolina Regulation 61-66 South Carolina Regulation 61-79 South Carolina Regulation 61-99 South Carolina Regulation 61-104	Completed	Issued in 2006.
Operational Environmental Plans and Permits		
BAQ Air Operating Permit 40 CFR 71 South Carolina Regulation 61.62-70	In progress	BAQ Air Operating Permit will be completed approximately 2 years prior to MFFF operations.
Risk Management Plan 40 CFR §68.130 Tables 1 & 3 South Carolina Regulation 61.62-68	Not required	MFFF will impose administrative limits on 40 CFR §68.130 and South Carolina Regulation 61.62-68 extremely hazardous chemicals, which will preclude the need for a Risk Management Plan.
BWQ Utility Water Permit 40 CFR 122 South Carolina Regulation 61-9 South Carolina Regulation 61-67	In progress	BWQ Utility Water Permit will be completed approximately 2 years prior to MFFF operations.
BWQ Sanitary Wastewater Operating Permit 40 CFR 122 South Carolina Regulation 61-9 South Carolina Regulation 61-67	In progress	BWQ Sanitary Wastewater Permit will be completed approximately 2 years prior to MFFF operations.
BLWM UST Operating Permit 40 CFR 112 40 CFR 280 South Carolina Regulation 61-92	In progress	BLWM UST Operating Permit will be completed approximately 2 years prior to MFFF operations
Spill Prevention Control and Countermeasures (SPCC) Plan 40 CFR 112 Section 110 South Carolina Regulation 61-9	In progress	SPCC Plan will be completed approximately 2 years prior to MFFF operations
BWQ Domestic Water Distribution Operating Permit 40 CFR 141 South Carolina Regulation 61-58 South Carolina Regulation 61-71 South Carolina Regulation 61-101	In progress	BWQ Domestic Water Permit will be completed approximately 2 years prior to MFFF operations.
BLWM Resource Conservation and Recovery Act (RCRA) Generator Identification Number South Carolina Regulation 61-79	In progress	BLWM RCRA Generator ID number will be obtained approximately 2 years prior to MFFF operations.

Table 10.4-1. Status of Federal, State and Local Licenses, Permits and Approvals (continued)

Requirement	Status	Comments
Bureau of Land and Waste Management **RCRA Part B Permit** South Carolina Regulation 61-66 South Carolina Regulation 61-79 South Carolina Regulation 61-99 South Carolina Regulation 61-104	Not required	Generated hazardous waste will be stored and accumulated for less than 90 days prior to being sent to SRS, which will preclude the need to obtain a RCRA Part B Permit.
Waste Minimization and Pollution Prevention Plan 40 CFR 261 40 CFR 262 40 CFR 264 40 CFR 268 South Carolina Regulation 61-66 South Carolina Regulation 61-79 South Carolina Regulation 61-99 South Carolina Regulation 61-104	In progress	Construction Waste Minimization and Pollution Prevention Plan will be updated approximately 2 years prior to MFFF operations.
Emergency Planning and Community Right-to-Know Notifications 40 CFR 355 40 CFR 372	Completed	MFFF expects to report as part of the SRS program.

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11. PLANT SYSTEMS

Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) systems and features facilitate normal operation of the physical facility and fuel fabrication processes, as well as perform safety functions. This chapter provides a description of the following major MFFF features and systems:

- Heating, ventilation, and air conditioning (HVAC) and confinement systems
- Electrical power systems
- Instrumentation and control systems
- Material handling equipment
- Fluid transport systems
- Fluid systems
- Heavy lift cranes.

11.1 HVAC AND CONFINEMENT SYSTEMS

The MFFF handles plutonium in the form of solutions, powders, and pellets. The dispersal hazard of nuclear material arises from possible migration of plutonium and its by-products from process equipment, gloveboxes, or fuel rods, into the work place or the environment. Confinement systems protect workers, the public, and the environment from exposure to radioactive materials.

Safety principles implemented to prevent the dispersal of nuclear material are based on the organization of the facility into multiple tiers of confinement consisting of static barriers and dynamic confinement systems. Structures, systems, and components (SSCs) of the static and dynamic confinement systems are organized into three confinement levels: primary, secondary, and tertiary confinement. Each confinement level consists of static confinement barriers and dynamic confinement HVAC systems. The multiple levels of confinement are the basis for the division of the MOX Fuel Fabrication Building into confinement zones (i.e., C1, C2, process cells, C3, and C4). Pressure gradients between zones ensure that air leakage flows from the zones of lowest contamination risk to zones of increasing contamination risk. For example, the contamination risk in process cells and C3 zones is higher than in C2 zones. Therefore, process cells and C3 zones are maintained at a negative pressure with respect to C2 zones, which ensures that a leak between the zones is from the C2 zone to the process cell or C3 zone.

Primary confinement mainly consists of process equipment, gloveboxes, rods, and 3013 containers. The interior of these enclosures is classified as a C4 zone. Primary confinement SSCs are installed immediately around the radioactive materials and prevent dispersion of radioactive material into working areas and the environment. This allows personnel to move about and perform their assigned tasks without wearing respiratory protection. Primary confinement includes at least one static confinement barrier, and in most cases primary confinement also includes a corresponding HVAC system, which is normally the Very High Depressurization Exhaust (VHD) system.

Secondary confinement consists of process rooms, which are designated C3 zones. Secondary confinement SSCs provide defense-in-depth to primary confinement protection against release of

radioactive material. Secondary confinement includes static barriers (e.g., process room walls, floors, and ceilings surrounding gloveboxes) and the associated HVAC system, which is normally the High Depressurization Exhaust (HDE) system.

Tertiary confinement consists of rooms designated as C2 zones and process cells. Tertiary confinement SSCs provide an additional barrier (defense-in-depth) to the release of radioactive material. Tertiary confinement includes static barriers (e.g., the walls, floors, and ceilings surrounding the remaining portions of the MOX Processing (MP) and Aqueous Polishing (AP) areas) and their associated HVAC systems, which is normally the Medium Depressurization Exhaust (MDE) system for C2 zones and the Process Cell Exhaust (POE) system for the process cells.

The dynamic confinement HVAC systems and static confinement barriers are discussed below.

11.1.1 Very High Depressurization Exhaust System

The VHD system:

- Maintains a negative pressure in the C4 (glovebox) relative to the C3 (process room) confinement zones
- Filters contaminants from glovebox exhaust air, various process units, and the pneumatic transfer systems prior to discharge through the MOX Fuel Fabrication Building stack
- Dilutes gases, including potentially flammable gases, and removes heat that is generated by equipment in the gloveboxes.

The VHD system provides confinement of radioactive material within associated gloveboxes by continuously maintaining a minimum differential pressure of approximately -1.2 in water gauge between the C4 and C3 confinement zones. The glovebox atmosphere is exhausted through two stages of high-efficiency particulate air (HEPA) filters at the glovebox boundary (C4 zone boundary), one stage of HEPA filters at the process room fire area boundary (C3 zone boundary), and two stages of final HEPA filters prior to being discharged to the atmosphere through the MOX Fuel Fabrication Building stack. These HEPA filters have a minimum removal efficiency of 99.97% for 0.3 micron particles as tested by the manufacturer. Air or gas supplied to the gloveboxes is supplied through two stages of HEPA filters. The filters on the supply and exhaust of each glovebox confine radioactive materials within the glovebox as close to the point of origin as practical.

The VHD system is two parallel subsystems consisting of piping, valves, dampers, fans, and filters. Exhausts from the main VHD subsystem and the laboratory subsystem are separated until commingled in the plant vent stack. This minimizes the formation and accumulation of ammonium nitrate within the system. The VHD subsystem has a total of eight exhaust fans. Each subsystem exhaust flow is normally maintained by two of the four 100%-capacity exhaust fans located downstream of two 100%-capacity final filtration units. The system is sized to maintain a minimum airflow velocity of 125±5 fpm through a hypothetical breach in a glovebox equivalent to two open 8-inch diameter glove ports. As noted above, the VHD exhaust fans

discharge to the MOX Fuel Fabrication Building stack, which is continuously monitored for radiation.

11.1.2 High Depressurization Exhaust System

The HDE system:

- Maintains a negative pressure in the C3 (process room) confinement zone relative to the C2 confinement zone
- Ventilates the emergency power supply rooms serving the VHD, HDE, and POE fans and fan rooms and ventilates the plutonium storage areas
- Filters contaminants from C3 exhausted gases prior to discharge through the MOX Fuel Fabrication Building stack
- Maintains an environment suitable for operating personnel.

The HDE system confines radioactive materials within process rooms by continuously maintaining a differential pressure between the C3 and C2 confinement zones. The rooms in the C3 confinement zone consist largely of process rooms containing gloveboxes. Process room air is exhausted through one stage of HEPA filters downstream of the C3 boundary, and two stages of final HEPA filters prior to being discharged to the atmosphere through the MOX Fuel Fabrication Building stack. Air is supplied to the process rooms through one stage of HEPA filters. The filters on the supply and exhaust of the process rooms are provided to confine radioactive materials within the process room as close to the point of origin as practicable.

The HDE system consists of ductwork, dampers, fans, and filters. HDE flow is maintained by one or both of the 100%-capacity exhaust fans located downstream of two 100%-capacity trains of final filtration units. As noted above, the HDE exhaust fans discharge to the MOX Fuel Fabrication Building stack, which is continuously monitored.

11.1.3 Medium Depressurization Exhaust System

The MDE system:

- Maintains a negative pressure in the C2 confinement zones relative to the C1 zones
- Filters contaminants from the exhaust air prior to discharge through the MOX Fuel Fabrication Building stack
- Maintains an environment suitable for operating personnel.

The MDE system confines radioactive material within the MOX Fuel Fabrication Building by continuously maintaining a differential pressure between the C2 and C1 zones. The MDE system exhausts air from rooms in the MOX Fuel Fabrication Building designated as C2 confinement areas, except those rooms requiring cooling during emergency operation. The rooms in the C2 confinement zone consist largely of process unit control rooms, electrical rooms, and manufacturing process rooms for operations associated with the following: 3013 container

receiving, unpacking, and nondestructive assay activities; rod storage and inspection; assembly mounting, inspection, and storage; and fuel cask loading.

The MDE system consists of ductwork, filters, dampers, and fans. MDE flow is maintained by one or both of the 100%-capacity exhaust fans located downstream of the final filtration units. As noted above, the MDE exhaust fans discharge to atmosphere via the MOX Fuel Fabrication Building stack, which is continuously monitored.

11.1.4 Process Cell Exhaust System

The POE system:

- Maintains a negative pressure in process cells relative to the C2 confinement zones
- Filters contaminants from process cell exhaust air prior to discharge through the MOX Fuel Fabrication Building stack
- Maintains an environment suitable for the manufacturing process.

The POE system confines radioactive materials within process cells by continuously maintaining a differential pressure between process cells and the C2 confinement zones. The system exhausts air from process cells in the AP Area. These rooms contain welded process equipment and are not normally accessible.

The POE system consists of ductwork, filters, dampers, and fans. Exhaust flow is maintained by one or both of the 100%-capacity exhaust fans located downstream of two 100%-capacity final filtration units. As noted above, the POE exhaust fans discharge to atmosphere via the MOX Fuel Fabrication Building stack, which is continuously monitored.

11.1.5 Static Confinement Barriers

Static barriers restrict dispersion of radioactive material out of a confinement boundary. Static barriers include 3013 containers and shipping packages, transfer containers, process equipment, gloveboxes, waste containers, fuel rod cladding, MOX fuel shipping casks, process enclosures, and HVAC ductwork and filters.

Plutonium received and stored at the MFFF is contained in U.S. Department of Energy (DOE) standard 3013 containers. The 3013 container provides primary and secondary confinement for plutonium that is received in the MFFF after the container is removed from a shipping package and during storage prior to opening the container to remove the plutonium for processing. The container consists of two individually sealed nested containers. The inner container provides primary confinement for the plutonium in the container. The outer container provides secondary confinement. The inner and outer containers are constructed of stainless steel and are sealed by welding.

Transfer containers are used to transport fuel material, waste, and samples inside the C2 confinement boundary. They transfer MOX fuel material and components from one point to another in the process and maintain structural integrity to preclude breaching of the confinement

boundary. Various transfer containers including reusable cans, jars, casks, and pots are used in the MOX facility.

Process equipment in the AP process units provides primary confinement of the radioactive materials contained in the vessels. AP equipment consists of vessels, pump housings, and piping. Vessels are of welded construction and many are maintained at a negative pressure with respect to the surrounding process cell to ensure that a leak is into the vessel. MP process equipment (e.g., the sintering furnaces) provides primary confinement of the fuel pellets during the sintering process. These furnaces are contained within a welded steel jacket under a slight positive pressure to prevent oxygen from entering the furnaces. The gas leaving the furnace is cooled and filtered prior to being exhausted.

Gloveboxes are single or multiple enclosures that are grouped together and that house process equipment and utility systems to maintain confinement of radioactive or toxic materials while providing access to the equipment for operations and maintenance activities. When dispersible nuclear materials such as powders, pellets, and liquids are not in qualified containers, gloveboxes serve as the primary containment boundary. They provide a static confinement barrier to the dispersion of materials and work in concert with the VHD system to maintain a differential pressure between the internal and external atmospheres of the glovebox. This differential pressure ensures that leakage across the glovebox confinement boundary is inward, from areas of lesser contamination potential to areas of greater contamination potential.

MOX transuranic wastes are packaged in waste containers. The waste containers provide primary and secondary confinement for contaminated material accumulated during plant operations prior to shipment for disposal. Waste containers used for the packaging and shipment of transuranic waste include drums and B-25 waste boxes. The B-25 waste boxes are typically used for shipping contaminated HEPA filters. The waste drums are used for containing various other types of solid waste material. Primary confinement is provided by packaging within the waste containers.

Sintered fuel pellets are inserted into zirconium alloy cladding within a glovebox. After insertion of the spring and plug, the rod is pressurized with helium and the seal is welded. Following seal welding, the fuel rod cladding provides primary containment for the radioactive material in the fuel pellets.

MOX fuel shipping casks contain fuel assemblies for shipment. The MOX fuel shipping cask is a Title 10 Code of Federal Regulations (CFR) Part 71-certified stainless steel cylindrical vessel with an upper double containment closure lid that provides leak tight secondary confinement for a payload of up to three fresh MOX fuel assemblies. The fuel assemblies are supported by a strongback assembly. The strongback assembly provides geometric stability and neutron poisoning for the fuel assemblies.

Process enclosures provide static secondary and tertiary confinement for the protection against the release of hazardous and radioactive material. Walls, floors, and ceilings of the MOX Fuel Fabrication Building and process cells provide an additional barrier to the release of radioactive materials. Static confinement barriers include supplemental provisions around openings (for

example, personnel or equipment access or HVAC ducts) to reduce the risk of contamination leaks.

While the HVAC systems discussed earlier in this section provide dynamic confinement to various confinement zones, the piping/ductwork and filters provide a static boundary for the confinement of radioactive material within the dynamic system. The ductwork is designed to withstand the maximum positive and negative pressure that could occur at each point in the system under normal and upset conditions, including rapid damper closure. The final filter units are protected from the pressure effects of a tornado by tornado dampers.

11.2 ELECTRICAL POWER SYSTEMS

MFFF electrical power systems provide and distribute power at the required voltages and frequencies for alternating current (AC) loads and direct current (DC) loads throughout the plant. The electrical power systems provide power to appropriate designated loads during normal operation, abnormal operation, design basis accident conditions, and loss of offsite power conditions. The MFFF electrical system is comprised of two major subsystems:

- Normal Power system (AC and DC)
- Emergency Power system (AC and DC).

The Normal Power system provides power for MFFF loads during normal plant operations. The normal source of power for the Normal Power system is offsite power. The Normal Power system is equipped with a standby source of power that is capable of carrying the full load of the MFFF, should the offsite source of power be unavailable. If the Normal Power system becomes unavailable, the Emergency Power system provides power to emergency loads for IROFS components.

11.2.1 Normal Power System

The Normal Power system consists of the Normal AC Power system, standby AC power equipment, and the Normal DC Power system. The Normal Power system supplies power to loads throughout the MFFF. During normal operating conditions, the Normal Power system receives power from two sources of offsite AC power. If both offsite power sources fail, the Normal Power system supplies power to essential loads from standby generators, uninterruptible power sources, and batteries.

The Normal AC Power system is a two-source, primary or secondary selective system. The normal source of power for the Normal AC Power system is a Savannah River Site (SRS) 13.8-kV electrical substation. Two 13.8-kV power feed circuits (feeds 1 and 2) are provided from the SRS substation to the MFFF. Via a 15-kV main circuit breaker, each offsite 13.8-kV feed supplies a separate 13.8-kV – 4.16-kV station service transformer that reduces incoming offsite power to 4160-V to provide a source of normal AC power in the MFFF. Each station service transformer is sized to carry the entire electrical load of the MFFF. Each incoming 13.8-kV feed is isolated from the other, but each is capable of providing an alternate power supply for the other 4160-V normal switchgear bus. Normal AC power is distributed within the MFFF from these two 4160-V normal switchgear buses. This electrical system configuration allows rapid

restoration of power upon loss of a single 13.8-kV primary feeder, 15-kV main circuit breaker, 13.8-kV-4.16-kV station service transformer, 4.16-kV transition bus, or 4.16-kV cross connection bus, and provides flexibility to remove 13.8-kV equipment and normal 4.16-kV buses from service for maintenance.

If the normal power source is unavailable, two standby generators provide power to the 4,160-V normal switchgear buses, via a paralleling bus and associated circuit breakers. Upon loss of normal power, the standby generators provide power for continued operation, limited operation, and safe shutdown and monitoring of MFFF equipment and systems. The standby generators provide AC power to loads that are required to shut the MFFF processes down in a safe and orderly manner and provide power to life safety loads and IROFS. The loads applied to the normal switchgear buses, when powered by the standby generators, are divided into two groups. Load group 1 is the highest starting priority load group and includes the emergency bus loads and life safety loads. Load group 2 is the second priority load group and includes non-emergency loads, such as process loads and non-IROFS ventilation loads. Emergency bus loads are connected to the 4.16-kV normal power bus first, followed by load group 2. If only one of the standby generators is available, the Utility Control system electrical distribution system programmable logic controller allows the start of only load group 1.

The Normal DC Power system provides 125-VDC power to energize and de-energize the Normal Power system trip and closing relay coils for low- and medium-voltage switchgear breakers and other normal DC power loads.

The Normal DC Power system battery converter/chargers are powered from a 480-VAC normal power source. Each converter/charger has a nominal output of 125-VDC. The converter/chargers have ample capacity to supply the steady-state loads under any plant condition while simultaneously recharging the associated battery. Each Normal DC Power system battery is designed to carry its connected load for one hour.

11.2.2 Emergency Power System

The Emergency Power system provides power to IROFS if power from the Normal Power system and power from the standby generators are both lost. The Emergency Power system is designed to operate after a design basis event. The Emergency AC Power system will operate in the event of loss of normal AC power, failure of automatic 4160-V bus transfer, and coincidental failure of the standby generators. Under this combination of circumstances, the 4160-V emergency buses automatically isolate, and the emergency generators start and connect to the emergency buses to restore power. The Emergency Power system is a redundant, independent, qualified electrical distribution system that meets single failure criteria. The use of separate and redundant trains and channels ensures that no single failure, unusual event, or accident will result in the loss of a protective function. Either of the two redundant, independent trains of the Emergency Power system is sufficient to ensure that necessary MFFF safety functions are performed.

The Emergency Power system provides power to IROFS loads, including the VHD, POE, and HDE exhaust fans, protective alarm and communications systems as dictated by the system requirements, and safety monitoring (seismic detection and stack monitoring). The Emergency

Power system consists of two independent 4.16-kV emergency buses. Each 4.16-kV emergency bus is normally powered by its associated (same train) normal 4.16-kV normal bus via an air-operated circuit breaker on the emergency bus. Each 4.16-kV emergency bus can also be powered from an associated dedicated 4.16-kV emergency generator. The emergency buses are the source of power for lower voltage downstream emergency power loads.

The emergency generators automatically start if normal power fails for two minutes, or if the normal power is degraded for thirty seconds, and if the standby generators fail to start. Once power is restored to the emergency buses, via the emergency generators, loads are then automatically or manually placed onto the buses based on their control scheme and procedures. The emergency generators can be started or stopped locally, or from the associated emergency control room. The capacity of each emergency generator is 1500 kW. The primary safety function of each emergency generator is to provide power for VHD, HDE, and POE fans, in order to maintain confinement. Each emergency generator is designed to provide power for these fan loads and maintain a design margin of 10%.

The Emergency DC Power system provides a source of 125-VDC power sufficient to supply DC IROFS loads, and to energize and de-energize Emergency Power Distribution system trip and closing relay coils for low- and medium-voltage switchgear breakers. The Emergency DC Power system consists of two redundant, independent trains (Train A and Train B), and satisfies the single failure criterion. Each train of the Emergency DC Power system is powered from a separate 480-VAC source, via battery chargers. Upon loss of the 480-VAC power source, the Emergency DC Power system batteries assume the system load. The chargers have ample capacity to supply the steady-state loads under normal and abnormal plant conditions while simultaneously recharging the associated battery. The battery of each train is designed to power the connected load for one hour. Sufficient physical separation, electrical isolation, and redundancy are provided to prevent a fault in one train of the Emergency DC Power system from affecting the other train.

11.3 INSTRUMENTATION AND CONTROL SYSTEMS

The MFFF Instrumentation and Control (I&C) systems monitor and control the manufacturing process systems, MFFF utility, safety, and emergency systems. The I&C systems control MFFF parameters during normal and transient conditions to ensure that limits are not exceeded, and to ensure the required quality of the product. I&C systems also provide signals to control equipment that prevents and/or mitigates faulted conditions.

The MFFF I&C systems are highly automated and are built around programmable logic controllers. Sensors and instruments are connected to the controllers. Control signals from the controllers are transmitted to control actuators using either field bus technology or traditional hard-wired methods. The controllers are linked to form a local area network. Operator workstations are linked to the controllers to form a local area network. Controllers and operator workstations are also linked to the process management systems to form a local area network.

MFFF operators monitor systems and supervise the operation of automatic controls from workstations located in MFFF control rooms, as follows:

- Polishing and Utilities Control Room
- MP Area Control Rooms (MP Processes)
- Alternate Utilities Control Room
- Emergency Control Room A
- Emergency Control Room B.

The Polishing and Utilities Control Room is located in the Shipping and Receiving Building and is the only MFFF control room that is continuously staffed. For that reason, the utilities, fire detection, and health physics monitoring equipment are located there. Other MFFF control rooms are unoccupied unless needed (e.g., controlling ongoing processes). Control rooms for the MP process units are distributed throughout the MP area and are generally located near the process units. The Alternate Utilities Control Room provides utility systems controls that are redundant to those in the Polishing and Utilities Control Room. Two separate and independent Emergency Control Rooms are provided for emergency conditions and are located in the Shipping and Receiving Building.

The MFFF I&C systems are the:

- MP and AP process control system
- Utility control system
- Emergency control system.

11.3.1 MP and AP Process Control Systems

The MP and AP processes are controlled by three control systems:

- Normal control system
- Personnel and Equipment Protection (PEP) control system
- Safety control system.

The normal control system controls normal MFFF manufacturing and processing operations. The normal control system performs monitoring and control functions commonly associated with plant automation and supervisory control, including equipment and process shutdown to safe failure modes upon detection of abnormal operating limits and states. The PEP control system performs monitoring and control functions necessary to protect personnel from industrial hazards and minimizes danger to MFFF equipment and property. The PEP control system operates independently of the normal control system. Actions associated with protective control functions have precedence over, and automatically override, normal control actions.

The safety control system performs monitoring and control functions necessary to meet the applicable performance criteria in 10 CFR §70.61. The safety control system operates independently of the normal and PEP control systems. Actions associated with safety control functions have precedence over, and automatically override, normal and PEP system control actions.

11.3.2 Utility Control System

The Utility Control system ensures that the MFFF support (utility) systems operate in accordance with specified parameters. The utilities systems consist of the HVAC system, the electrical power control system, the reagent fluids and gases systems, process heating and cooling water, steam systems, and effluents control system. The Utility Control system is composed of the following control subsystems:

- Normal utility control subsystem
- Auxiliary utility control subsystem.

The normal utility control subsystem controls the normal operation of MFFF utility systems. The auxiliary utility control subsystem is separate and independent, and assumes control over selected utility systems if the normal utility control subsystem fails.

11.3.3 Emergency Control System

The Emergency Control system ensures selected process and facility support systems operate as needed during emergency conditions, and prevent criticality events that could result from an earthquake. The Emergency Control system provides a limited number of automatic and manual controls over power dispatch and control, ventilation, and selected AP and MP functions that are required to operate or continue to function during and following certain very high consequence events, such as a fire or a design basis earthquake. The Emergency Control System performs the safety functions of the Utility Normal and Auxiliary Control Systems in the event they become inoperative.

The Emergency Control system consists of two separate, redundant, and independent trains, A and B, having separate control panels located in separate emergency control rooms. A seismic monitoring and trip feature of the Emergency Control system satisfies the criteria of Regulatory Guide 3.17. Each train contains four seismic sensors, which are sensitive to ground acceleration. One sensor in each train is installed outside the MFFF buildings in the ground. The three other sensors are installed inside the MFFF buildings. The control logic is to detect the presence of ground acceleration. If two out of three seismic sensors in the MFFF buildings in either train trip, a two-out-of-three high seismic alarm is generated and nonessential electrical loads are tripped off-line and selected systems are isolated. The Emergency Control system is qualified and capable of providing the limited control necessary to maintain selected systems operational under abnormal conditions associated with a fire or a design basis earthquake.

In addition to control of the ventilation and power control functions required to maintain confinement, the Emergency Control system provides control over a limited number of utility functions. In the event of a significant seismic event, reactive gas and flammable fluid supplies are automatically isolated from the Aqueous Polishing Area (BAP) and the MOX Processing Area (BMP), and miscellaneous power to most actuators is tripped. Some instrument power may continue uninterrupted. This action establishes a safe state that stops the machinery in a safe configuration “as is” or stops the process flow by closing valves or stopping the process.

11.4 MATERIAL HANDLING EQUIPMENT

MFFF process material is handled in dry form by material handling equipment located in the MP Area, certain AP Areas, and the Shipping and Receiving Area. Material handling in aqueous form is performed by fluid transport systems, discussed below.

Material handling equipment performs safety and nonsafety functions. The safety functions are performed during normal operations, upset conditions, accidents, and natural phenomena events. The nonsafety functions are performed during specific equipment or system operating modes in support of MFFF production. The MFFF material handling equipment:

- Transfers MOX fuel material and containers from one point in the process to another
- Maintains structural integrity and control of process containers to ensure that the confinement boundary is not breached
- Maintains structural integrity and control of process containers to ensure that criticality control functions are performed
- Transfers tooling and equipment spare parts from point to point inside the glovebox system during maintenance operations.

Different types of equipment are used to move dry fuel production material, depending on the form of the material (powders, pellets, fuel rods, fuel assemblies, or waste), the container used to carry it, and the configuration of the process equipment that receives the container. Each material form is transferred within containers designed to meet applicable design requirements for handling that specific material form.

Material handling equipment is used to transport production material in bulk powder form by gravity feed, vibrating conveyor, and direct pneumatic transfer. Material handling equipment used to transport containers of production material in powder form includes bridge cranes, roller conveyors, ball-screw elevators, rotary tilters, turntables, pick-and-place robotics equipped with gripping manipulators, and pneumatic transfer equipment. Material handling equipment used to transport pellets individually includes vibrating conveyors, conveyor belts, and robotics. Material handling equipment used to transport containers containing pellets includes conveyors, turntables and elevators. Material handling equipment used for individual fuel rods includes roller drives, notched belt conveyors, roller conveyors, pick-and-place cranes, lifting mechanism, and indexing tables. Material handling equipment used for trays of fuel rods includes elevators, stacker retrievers, chain conveyors, and horizontal transfer tables. Material handling equipment used for fuel assemblies includes the overhead trolley and hoist system running on a monorail, fixed-geometry handling equipment, mobile transfer pallets, and bridge cranes. Material handling equipment used to transport waste material includes conveyors, jib cranes, and bridge cranes. Heavy lift cranes are discussed below.

11.5 FLUID TRANSPORT SYSTEMS

The MFFF fluid transport systems consist of the mechanical components such as welded equipment and piping that handle process and utility fluids during AP, MP, and utility processes.

Welded equipment is stationary process equipment made of fabricated metal construction and located in the AP plant systems area. The following types of process equipment and vessels are commonly known as welded equipment components in the MFFF plant systems:

- Criticality safe vessels are designed and constructed for process fluids that pose a criticality risk.
- Conventional vessels are designed and constructed to store utility and reagent fluids. Conventional tanks are this type of process vessel, use conventional design geometry, and are constructed in accordance with good engineering practices and national codes.
- Standardized equipment use standardized design and construction approach to perform process specific functions in the AP plant systems. Separator pots, leak detection pots, demisters, low-pressure airlifts, ejectors, and siphons are this type of process equipment.
- Process columns are used for mass transfer processes. Pulsation columns, rectification columns, packed columns, scrubbing columns, and columns with trays are this type of process equipment.
- Exchangers are used to transfer process heat loads. Evaporators, condensers, shell and tube exchangers, finned tube exchangers, pipe jacketed heaters and coolers are this type of process equipment.

Miscellaneous components include process equipment such as pumps, filters, mixing tanks, and precipitators. Components for handling fluids with radiological characteristics and that require opening for maintenance are located in gloveboxes. Fluid transport system piping layout is designed to preclude nuclear criticalities.

Fluid transport components are designed and constructed to achieve safe, reliable, and efficient transfer of fluids within the MFFF plant systems. Components associated with the transfer of radiological fluids have adapted low pressure and low temperature process technologies. Fluid transport system components are designed to minimize fluid traps and dead spots.

The material of construction for the fluid transport system (FTS) components is selected from the basic materials that are compatible with the physical and chemical characteristics of the process fluids, which includes consideration of corrosion where applicable. Stainless steel 304L or 316L and specialty materials titanium and zirconium are used for FTS category 1 components that handle process fluids with acidic and radiological properties. FTS category 2 and 3 components handling process fluids that are acidic or alkaline in nature are also constructed from stainless steel 304L or 316L materials.

The materials for components are specified in accordance with the material specifications of the American Society of Mechanical Engineers (ASME) or American Society for Testing and Materials (ASTM). ASME materials are used for the fabrication of equipment and piping components that are built to the requirements of ASME Section VIII, *Pressure Vessels*, 1996 Edition through 1998 addenda, and American National Standards Institute (ANSI)/ASME B31.3, *Process Piping*, 1996 through 1998 addenda. ASTM materials are used for other components.

The corrosion allowance for the construction materials is specified for each component in accordance with industry practices and from experience at the La Hague facilities.

To limit system corrosion through the use of materials compatible with the surrounding environment and system fluids, corrosion allowances have been applied to the FTS component design and implemented on the following basis:

- Compatible materials of construction are selected that are known to have low corrosion kinetics for the process fluid(s) in a given process and surrounding conditions. The corrosion allowance in the engineering design development is accounted in accordance with national code practices.
- Design basis applied to FTS components (equipment and piping components) take into consideration the galvanic corrosion phenomena. The considerations applied to eliminate occurrences of galvanic corrosion avoid use of dissimilar metal joints with the MFFF plant systems and include:
    - Use of insulating gaskets, sleeves, and washers to prevent propagation of galvanic current when joints with dissimilar metals known for galvanic corrosion are used.
    - Applications of such sleeve fittings or flanged joints receive periodic inspection, maintenance, and surveillance.

An FTS component using such an application and part of radiological process units is located in a glovebox. The layout of the fluid transport systems provides:

- Ease of egress and evacuation in occupied rooms
- Passageways for the movement, repair, installation, or removal of components
- Centralized piping in dedicated galleries, to the extent practical.

The welded equipment and piping components handling radiological fluids are constructed of fully welded construction and are located in the process cell confinement. Radiological fluid bearing components that do not permit fully welded construction are installed in a glovebox confinement. The design of the FTS components is specified with appropriate corrosion allowances. The welded joints construction conformance is appropriately radiographed. The floor in the process cells is lined with a drip tray and has an associated sump with level monitoring to collect and detect potential leakage from the process. Drip trays are also mounted under vessels that contain radiological fluids to divert leakage to floor drip trays and sumps.

Radiological fluids are contained within at least two levels of confinement and are transferred using static transfer means, such as gravity flow, airlifts, air jets, and steam jets when practical. Piping components carrying radiological fluids are either fully welded with double-wall construction between two confinements, or installed in gloveboxes / process cells.

11.6 FLUID SYSTEMS

The MFFF fluid systems described in this section are the fluids, gases, and reagents that do not contain radioactive material. Fluid systems are grouped into three system categories:

- Mechanical Utility Systems – These systems include various water and air supply systems, diesel fuel systems, the process steam system, the decontamination solution system, and the vacuum system for radiation monitoring.
- Bulk Gas System – These systems include the nitrogen, argon/hydrogen, helium, oxygen, methane/argon, and nitrogen oxide systems.
- Reagent Systems – These systems include chemical solutions that are consumed in the AP process or in the laboratory.

11.6.1 Mechanical Utility Systems

The mechanical utility systems are:

- HVAC Chilled Water
- Process Chilled Water
- Demineralized Water
- Process Hot Water
- Process Steam
- Building Services
- Emergency and Standby Diesel Generator Fuel Oil
- Service Air
- Instrument Air
- Breathing Air
- Decontamination
- Radiation Monitoring Vacuum.

The HVAC Chilled Water system supplies chilled water and cooling water to meet the requirements of the MOX Fuel Fabrication Building HVAC system. The system external loop supplies chilled water to the building's main cooling coils, to air handling units and individual room fan coil units, and to the intermediate heat exchanger to indirectly cool the internal cooling water loop. The internal loop then supplies cooling water to individual room fan coil units throughout the building.

The Process Chilled Water system supplies chilled water for various AP and MP process and fluid system requirements. The system external loop supplies chilled water to some fluid systems equipment and the intermediate heat exchangers to indirectly cool the internal cooling water loops. The internal loops then supply cooling water to the process units and other fluid systems equipment. These closed internal loops maintain separation from the external loop to reduce the risk for dispersal of radiological and/or chemical contamination to the external cooling loop and the outside environment.

The Demineralized Water system supplies demineralized water to process equipment and utility systems. The system produces, stores, and transfers demineralized water. It supplies pressurized and unpressurized (i.e., gravity-fed) demineralized water to process equipment and utility systems for reagent preparation, solutions dilution, internal loop filling, humidification of sintering gas, general laboratory use, and miscellaneous process purposes.

The Process Hot Water system supplies superheated demineralized water and dilute hot nitric acid to process equipment. These include AP process heat exchangers in the Precipitation-Filtration-Oxidation unit, the Solvent Recovery unit, the Purification Cycle unit, and the Nitric Acid Recovery unit.

The Process Steam system generates and supplies steam to process equipment primarily in the AP area and collects and returns the condensate for reuse in the steam generation cycle.

The Building Services system provides potable water and drainage for personnel decontamination within the MOX Fuel Fabrication Building and potable water and sanitary drainage for the Service Air system.

The Emergency and Standby Diesel Generator Fuel Oil systems receive, store, and transfer fuel oil to their respective emergency and standby diesel generators. The Emergency Diesel Generator Fuel Oil system consists of two separate and independent fuel oil storage tanks and supply pumps, one for each emergency diesel generator. The tanks are installed within protected enclosures (vaults). The Standby Diesel Generator Fuel Oil system consists of a common storage tank, with a separate fuel oil supply to each standby diesel generator.

The Service Air system filters and pressurizes outside air, stores it in a receiving tank, and then filters and dries the air in preparation for use as service air. The system provides filtered air to the Instrument Air system. The system also supplies pressurized service air to the MOX Fuel Fabrication Building service air headers for maintenance and utility operations. The system consists of filters, compressors, receiving tanks, oil separators, coolers, and moisture separators.

The Instrument Air system receives service air, dries and filters it, and stores it in receiver tanks. The MFFF uses instrument air for:

- Air-operated valves, glovebox pneumatic actuators ("cylinders"), and HVAC dampers
- Ventilation and cooling air for gloveboxes and the pelletizing press bellows
- Bubbling air for level measurement and hydrogen dilution during normal operation
- Dry air for ventilation and cooling of the AP powder gloveboxes.

The emergency scavenging air subsystem is an independent subsystem of the Instrument Air system that provides a backup source of scavenging air in the event the Instrument Air system becomes unavailable, power is lost, or other off-normal conditions. Under such conditions, the emergency scavenging air subsystem provides scavenging air to prevent radiolysis-related hydrogen buildup.

The Breathing Air system supplies clean, dry breathing air to the MOX Fuel Fabrication Building breathing air headers for operational and emergency usage. To prevent cross-contamination, the Breathing Air system is an independent air supply system and cannot be connected to other air system. The system consists of compressors, purifiers (includes coalescing filters, desiccant dryers, activated carbon filters for removal of unpleasant odors and tastes, and final particulate filters), receiving tanks, and associated piping. Auxiliary breathing air is supplied by gas bottles.

The Decontamination system supplies a nitric acid solution for the decontamination of process equipment in the AP process and lab gloveboxes.

The Radiation Monitoring Vacuum system draws air into airborne radioactive particulate monitors (continuous air monitors) located throughout the MOX Fuel Fabrication Building. The system exhausts into the High Depressurization Exhaust system.

11.6.2 Bulk Gas Systems

The MFFF Bulk Gas systems are the:

- Nitrogen
- Argon/Hydrogen
- Helium
- Oxygen
- Methane/Argon
- Nitrogen Tetroxide.

The Nitrogen system provides gaseous and liquid nitrogen. An onsite gaseous nitrogen production system separates nitrogen from ambient air. The system supplies gaseous nitrogen for:

- Ventilation of BMP gloveboxes
- Sintering furnace airlocks (redundant backup)
- Calcination furnace scavenging
- Pressurization of the demineralized water surge tank
- Hydrazine and hydroxylamine nitrate tanks scavenging
- Backup to selected equipment and the pelletizing press bellows.

The system supplies liquid nitrogen from storage tubes to cool gamma spectrometry detectors and for miscellaneous laboratory uses. Vaporized liquid nitrogen is also used as the backup supply for gaseous nitrogen.

The Argon/Hydrogen system mixes gaseous argon and hydrogen to form an argon/hydrogen gas mixture that is supplied to the process electric sintering furnaces. (Premixed argon and hydrogen is available from cylinders as backup.) The argon gas is supplied from two argon vaporizing packages consisting of bulk liquid argon storage tanks, vaporizers, and associated instrument and piping components for mixing. The hydrogen gas is supplied from a tube trailer. Pure argon, with pure nitrogen as backup, is supplied to the sintering furnaces when required for purging.

The Helium system provides gaseous helium for use in fuel rod pressurization and inerting during fuel rod seal welding from a tube trailer supply.

The Oxygen system provides oxygen for the Homogenization unit calcination furnace. The system provides oxygen from onsite liquid oxygen storage tanks.

The Methane/Argon system provides a mixture of these gases for use as a quenching gas for personnel radiation monitors located throughout the MFFF.

The Nitrogen Tetroxide system vaporizes liquid nitrogen oxide and supplies it to the AP process for oxidation of plutonium nitrate in the purification cycle.

11.6.3 Reagent Systems

The Reagent systems are the:

- Nitric Acid
- Silver Nitrate
- Tributyl Phosphate
- Hydroxylamine Nitrate
- Sodium Hydroxide
- Oxalic Acid
- Diluent
- Sodium Carbonate
- Hydrogen Peroxide
- Hydrazine
- Manganese Nitrate
- Sodium Sulfite
- Sodium Nitrite
- Uranyl Nitrate
- Aluminum Nitrate
- Zirconium Nitrate.

The Nitric Acid system supplies nitric acid for various AP processes. The system also provides nitric acid for the preparation of hydrazine, oxalic acid, manganese nitrate, decontamination solution, zirconium nitrate, hydroxylamine nitrate, and silver nitrate reagents. Major components of the system are the nitric acid storage, drain, preparation, and buffer tanks, columns for nitric acid vent washing and gas stripping, and nitric acid transfer and distribution pumps.

The Silver Nitrate system mixes and provides a silver nitrate solution to the electrolyzers in the Dissolution and Dechlorination/Dissolution units. The major components of the system are the solid silver nitrate feeder, preparation, drain, and distribution tanks, and their associated pumps.

The Tributyl Phosphate system provides pure and 30% tributyl phosphate (TBP) to the Solvent Recovery unit where the recovered solvent is then used in the Purification Cycle. The major components of the system are the preparation and distribution tanks and transfer, distribution, and dosing pumps.

The Hydroxylamine Nitrate system provides hydroxylamine nitrate (HAN) for plutonium stripping in the Purification Cycle. The major components of the system are the HAN storage,

buffer, and preparation tanks, HAN stripping column, hydrazine and HAN effluents storage tank, and associated pumps.

The Sodium Hydroxide system provides a diluted sodium hydroxide solution to wash the solvent in the Solvent Recovery unit and provides sodium hydroxide for the gas scrubbing in the Dechlorination/Dissolution unit and Nitric Acid system, and for neutralization purposes in the Liquid Waste Reception unit. The major components of the system are the 10N preparation tank, which is located in the Reagent Processing Building; the 10N distribution tank and the 0.1N preparation and distribution tanks, which are located within the AP Area; and their associated pumps.

The Oxalic Acid system provides two different concentrations of oxalic acid for converting plutonium nitrate to plutonium oxalate in the Oxalic Precipitation and Oxidation unit. The major components of the system are the solid oxalic acid feeder, preparation, distribution, and buffer tanks, transfer and drain pumps, and break pots.

The Diluent system supplies hydrogenated tetrapropylene to the Purification and Solvent Recovery units for washing and for preparation of the TBP solvent solution. The major components of the system are the fresh diluent preparation and distribution tanks, fresh diluent transfer pump, tank vent adsorbers, and dosing pumps that supply diluent to various process users.

The Sodium Carbonate system supplies dilute sodium carbonate to the Solvent Recovery unit for washing. The major components of the system are the solid sodium carbonate feeder, preparation tank, transfer pumps, distribution tank, and dosing pumps.

The Hydrogen Peroxide system provides a dilute solution of hydrogen peroxide for valence adjustment of the dissolution solution in the Dissolution and Dechlorination/Dissolution units. The major components of the system are the hydrogen peroxide preparation tank, transfer pumps, distribution tank, drain tank, break pot, and dosing pump.

The Hydrazine system supplies hydrazine hydrate for the preparation of hydrazine nitrate, which is then mixed with hydroxylamine nitrate for use in the purification cycle. The major components of the system are the hydrazine hydrate storage tank and pumps; the hydrazine nitrate preparation and mixing reactors, pumps, and break pot; and the hydrazine vapor stripping column.

The Manganese Nitrate system provides manganese nitrate in solution for use as a catalyst in the Oxalic Precipitation and Oxidation unit. The major components of the system are the preparation and distribution tanks and dosing pump located in the AP Area.

The Sodium Sulfite system provides a sodium sulfite solution to the Dechlorination/Dissolution unit as a washing solution. The major components of the system are the solid sodium sulfite feeder, preparation tank, and transfer pump located in the Reagent Processing Building and the distribution tank, pumps, and break pot located in the AP area.

The Sodium Nitrite system provides a sodium nitrite solution to the Aqueous Liquid Waste Reception unit for treatment/destruction of azides in alkaline wastes. The major components of the system are the distribution tank and drum pump located in the AP area.

The Uranyl Nitrate system supplies a depleted uranyl nitrate solution to reduce the final isotopic composition of the uranium in the plutonium feed material in the Purification Cycle, Dissolution, and Dechlorination/Dissolution units. The major components of the system are the distribution tank, distribution pumps, and break pot. The system is located in the AP area.

The Aluminum Nitrate system supplies an aluminum nitrate solution to the Purification Cycle unit for solvent scrubbing. The major components of the system are the buffer tank and the dosing pump.

The Zirconium Nitrate system prepares a zirconium solution, which is supplied to the Purification Cycle and Acid Recovery units to prevent fluoride corrosion of those stainless steel vessels. The major components of the system are the preparation and distribution tanks, transfer pump, and dosing pumps.

11.7 HEAVY LIFT CRANES

Heavy lift cranes handle heavy loads, which are defined by NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants* as being loads greater than the weight of a single fresh fuel assembly and its associated handling tool. Cranes and hoists in the MFFF that have capacities greater than 1,800 lb are referred to as heavy lift cranes.

Critical loads are defined as those loads whose uncontrolled movement (drop or other mechanical impact) could result in unacceptable radiological doses. Loads other than critical loads are defined as noncritical loads.

There are no MFFF heavy lift cranes that handle critical loads as defined above. There are no MFFF heavy lift cranes that must retain their load during normal operation, design basis accidents (including a loss of electrical power), or design basis natural phenomena events.

Heavy lift cranes that travel over areas where safety or confinement SSCs are located must remain structurally intact under normal, accident, and design basis natural phenomena conditions.

The MFFF process heavy lift cranes and general information about maintenance cranes and hoists are provided below.

The bridge crane in the fresh fuel shipping package truck bay lifts inbound or outbound material and equipment. This includes empty inbound fresh fuel shipping packages removed from shipping vehicles.

The bridge crane in the fuel assembly storage area and fuel assembly packaging area transfers fuel assemblies to the fuel storage vault, and from the storage vault to the fuel assembly packaging area, where the assemblies are loaded onto a strongback. In the fuel assembly packaging area, the bridge crane transfers an empty fresh fuel package strongback from the

strongback insertion/extraction station to the assembly load/unload station, removes the strongback top plate to provide access for loading fuel assemblies, replaces the strongback top plate after fuel assemblies are loaded, and then transfers the loaded strongback from the assembly load/unload station back to the strongback insertion/extraction station.

The hoists for the fuel assembly area monorail are used to transfer fuel assemblies from the upending fixture to the different inspection stations in the fuel assembly area. Once inspections are completed, the fuel assemblies are transferred to the fuel assembly storage area.

The bridge crane in the fresh fuel shipping package handling area removes and replaces the fresh fuel shipping package impact limiters and package lids. This crane is also used for general maintenance purposes. The crane may be used to lift outbound packages loaded with fresh fuel.

The bridge crane storage and retrieval unit, located in the waste storage area, is used to transfer loaded pallets between the pallet conveyor and the pallet storage racks. The pallets contain four waste drums each.

The bridge crane in the PuO_2 receiving area is used to handle empty PuO_2 shipping package pallets.

The process jib crane located in an airlock is designed for transferring drums onto pallets for storage.

The two process handling monorail hoists located in the UO_2 receiving room are designed to pick up the tilting device that is to be attached to the UO_2 drum. Once the tilting device is attached, the handling monorail hoist lifts the tilting device and the UO_2 drum and transfers it to the emptying glovebox.

The process shipping package monorail hoist located in the pallet storage room is designed to transfer shipping packages from the inbound cargo restraint transporter table to the shipping package infeed conveyor.

Maintenance monorails and hoists, which are permanently installed, are provided in the MOX Fuel Fabrication Building, Emergency Diesel Generator Building, and the Emergency Fuel Storage Vault for general maintenance purposes. Additionally, some process rooms and process areas are equipped with embedded ceiling eyehooks for the attachment of portable hoists and winches. Portable cranes may also be used in process rooms and process areas where there are no permanently installed cranes or hooks.

12. HUMAN FACTORS ENGINEERING

Human factors engineering (HFE) is applied to the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) personnel activities that are designated items relied on for safety (IROFS). HFE is also applied to system interfaces and the supporting equipment and systems that control the environment in which the personnel activities are performed. This chapter describes the application of HFE to the MFFF.

Design of the facility is based on designs of existing AREVA NC facilities at La Hague and MELOX, with modifications to incorporate "lessons learned," to implement requirements of the U.S. Nuclear Regulatory Commission (NRC), and to accommodate characteristics of MFFF feed material. Existing designs of facilities, equipment, or systems that are adapted or modified for use in the facility are reviewed to evaluate the efficacy of human factors design elements. The depth and rigor of the evaluation are dependent on a determination of the complexity and importance to safety of the component or system, and consequences of human error.

12.1 PERSONNEL ACTIVITIES DESIGNATED IROFS

Control of the MFFF relies to a great extent on automated control systems for production quality and facility safety. The MFFF control systems are discussed in Section 11.3. MFFF operations staff perform the following types of tasks:

- Initiate batch or continuous operations
- Monitor the progress of the operations
- Perform quality control checks at preprogrammed process hold points
- Monitor and confirm the status of confinement systems, fluid systems, and other facility systems
- Respond to or recover from off-normal or emergency conditions/alarms, e.g. facility fire scenarios.

The highly automated nature of the facility limits the number of personnel activities designated IROFS (also called IROFS administrative controls). Those IROFS administrative controls, as identified in the integrated safety analysis (ISA), are governed by approved procedures. Examples include:

- Reviewing sample results in order to allow a process to feed forward
- Inputting data into safety programmable logic controllers
- Evacuation of an area in response to a glovebox differential pressure alarm
- Response to a high level alarm in a process vessel to prevent overfilling.

12.2 HUMAN FACTORS ENGINEERING DESIGN REVIEW

The HFE program includes identification of HFE programmatic goals, scope, and a description of plans for HFE review, HFE team makeup, and the processes for conducting HFE reviews. The ISA process identifies the sensors, instruments, actuators, and personnel actions that are

designated IROFS. The associated human system interfaces (HSIs) are then identified, and appropriate human performance requirements established, during the design process.

12.2.1 Scope and Goals

The scope of the MFFF HFE design review is IROFS administrative controls. The MFFF HFE program will include evaluations of maintenance/surveillances on IROFS systems or instrumentation and evaluations to ensure operators have the appropriate controls and instrumentation available to confirm proper operation of the safety systems and controls, including automated safety actions, confinement systems, HVAC systems, and alarms during both normal and off-normal or emergency conditions (e.g., facility fire scenarios). HFE principles are applied to the MFFF design based on human factors engineering industry guidelines. Applicable criteria from NUREG-0711, *Human Factors Engineering Program Review Model*, (1994) are also used as guidance for the design review. Evaluation of the characteristics of the HSI uses the applicable review guidance of NUREG-0700, *Human-System Interface Design Review Guidelines*, (Rev. 2).

The goals of the MFFF HFE program for IROFS administrative controls are to:

- Include HFE principles in the design such that the performance capabilities of MFFF personnel are not challenged.
- Verify that the design is appropriate with respect to HFE principles.
- Demonstrate the adequacy of the human factors design by integrated system validation and final HFE/HSI verification.
- Institute procedures that ensure HFE principles are appropriately applied to facility changes.

12.2.2 HFE Team Composition, Organizational Activity, and Responsibilities

The MFFF manager of the plant engineering function is responsible for implementation of the HFE program during the MFFF design and construction phases. The HFE team is responsible for execution and documentation of the HFE function, including:

- Recommending actions to ensure HFE principles are adequately reflected in the design
- Coordinating implementation of HFE recommendations
- Verifying implementation of HFE design criteria as part of the final design review.

During the operations phase, this function transitions to become a part of plant production, and the manager of the production function is responsible for implementation of the HFE program and leading the HFE team. The HFE team is composed of the manager of the production function (or his representative) and the lead engineer for controls and supplemented by other technical disciplines as appropriate. The HFE team ensures that HFE criteria are appropriately applied to IROFS administrative controls, with particular emphasis on review of plant changes, events and incidents, and procedures.

MFFF staffing levels are determined, in part, by evaluating the number of tasks required to be performed by operators, the complexity of the tasks, and the coincidence of the tasks for various plant operating conditions. The evaluation incorporates results from the functional allocation, task analysis, operating experience review, HSI design, procedure development, and the HFE verification and validation (V&V). The number and complexity of tasks determined from the startup and testing phase are factored into this evaluation.

12.2.3 Process and Procedures

HFE is applied to the MFFF in a structured approach using approved plans and procedures. The application of HFE is risk-informed and is conducted commensurate with the safety significance, complexity, and degree of human-system interaction.

The design review process includes:

- Functional allocation and task analysis
- HSI design, inventory, and characterization
- Identification of HFE V&V activities to support construction and startup.

12.2.4 Issue Tracking

Human engineering discrepancies (HEDs) are defined as departures from a benchmark of system design suitability for the roles and capabilities of the human operator. This may include a deviation from a standard or convention of human engineering practice, an operator preference or need, or an instrument/equipment characteristic that is implicitly or explicitly required for an operator's task, but is not provided to the operator.

HFE deviations discovered during the human factors review are resolved, or justification of the acceptability is documented, prior to Operations acceptance of the final design. HEDs are tracked to resolution.

12.2.5 Functional Grouping

Functional units of the MFFF are grouped by plant area or by control rooms. HFE design reviews are performed during final design for each plant area or control room where personnel actions designated IROFS, or where operations, testing, or maintenance activities associated with IROFS, are performed. The HFE design review process documents this review and confirms that the final design is acceptable for the applicable plant area or control room.

12.3 FUNCTIONAL ALLOCATION AND TASK ANALYSIS

Functional allocation is the process of assigning responsibility for function accomplishment to human or machine resources, or to a combination of human and machine resources. Functional allocation addresses the MFFF design goal to automate operations as much as practical. The MFFF functional allocation is based on the results of the process hazards analysis.

Task analysis is performed to evaluate the component's steps of a task in terms of the demands placed on the operator; the information required by the operator; the extent to which the task

requires reliance on, or coordination with, other personnel; and the relation of the task to other tasks. Task analysis identifies the specific operator and the operator's information and control requirements (e.g., instruments, controls, communication, instrument ranges) that enable the operator to perform the task. Task analysis considers representative tasks from the areas of operations, maintenance, test, inspection, and surveillance, and considers various plant operating modes. Task analysis also considers tasks for monitoring automated systems and responding to off-normal conditions. This analysis process will identify the causes, modes, and probabilities of human error. Identification of potential human error concerns is performed during the design process and provides for elimination or reduction in the probability of occurrence of human errors during the design process prior to construction.

12.4 HSI DESIGN, INVENTORY, AND CHARACTERIZATION

Functional allocation and task analysis are incorporated into the design of IROFS components (e.g., IROFS alarms, normal monitor displays, controls, and operator aids) during final design. Based on the results of the task analysis, the control, display, and communications equipment requirements for IROFS systems, facilities, and equipment that are operated and maintained by personnel or have a significant HSI are identified. Evaluation of the characteristics of the HSI incorporates the review criteria of NUREG-0700, Rev. 2, as applicable. The resulting HSI design addresses work environment, the work space layout, control panel and console design, control and display device layout, and information and control interface design. The HSI design avoids extraneous controls and displays, and minimizes the incorporation of information, displays, controls, and features that unnecessarily complicate operator activities.

12.5 PROCEDURE DEVELOPMENT

MFFF procedures for IROFS administrative controls incorporate HFE principles and criteria with other design criteria. As appropriate, these procedures include generic technical guidance, plant and system operations, abnormal and emergency operations, tests (e.g., preoperational, startup, and surveillance), and alarm response. MFFF procedures are described in Chapter 15.

12.6 TRAINING PROGRAM DEVELOPMENT

The operator training program for the MFFF addresses IROFS administrative controls. The operator training incorporates the results of the task analysis. MFFF training is described in Chapter 15.

12.7 VERIFICATION AND VALIDATION

Verification and validation (V&V) that the MFFF final design adequately incorporates HFE for IROFS administrative controls are completed prior to plant operation. The V&V process is conducted in accordance with MFFF design control and configuration management requirements, and includes:

- HSI task support verification
- HFE design verification
- Integrated system validation

- Human factors issue resolution verification
- Final HFE/HSI design verification.

12.7.1 HSI Task Support Verification

The MFFF HFE review of procedures verifies that the appropriate HSI provides alarms, information, and control capabilities required for personnel tasks as identified in the task analysis.

12.7.2 HFE Design Verification

The HFE review compares the HSI items inventoried, against the HFE criteria identified in NUREG-0700, Rev. 2, or MFFF-developed checklists. Resolution of identified discrepancies is documented prior to MFFF operation.

The final HFE/HIS design verification process includes verification of the needed controls and displays identified in the task analysis, categorizing each by type, and identifying the applicable HFE specifications and requirements prior to MFFF operation.

12.7.3 Integrated System Validation

The integrated system validation uses performance-based tests or reviews to ensure that the integrated system design of MFFF systems (i.e., hardware, software, and personnel elements) meets performance requirements and acceptably supports safe operation. Walk-throughs and talk-throughs of plant procedures are performed to determine the adequacy of HSIs to support plant operation.

12.7.4 Human Factors Issue Resolution Verification

The resolution of HEDs identified during the design process is verified. Any significant HFE issues are reviewed, dispositioned, and documented.

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13. SAFEGUARDS AND SECURITY

13.1 PHYSICAL PROTECTION

Duke Cogema Stone & Webster (DCS) has submitted under separate cover the Physical Protection Plan for the Mixed Oxide (MOX) Fuel Fabrication Facility.

13.2 TRAINING AND QUALIFICATION

DCS has submitted under separate cover the Training and Qualification Plan for Security Personnel for the MOX Fuel Fabrication Facility.

13.3 MATERIAL CONTROL AND ACCOUNTING

DCS has submitted under separate cover the Fundamental Nuclear Material Control Plan for the MOX Fuel Fabrication Facility.

13.4 SAFEGUARDS CONTINGENCY

DCS has submitted under separate cover the Safeguards Contingency Response Plan for the MOX Fuel Fabrication Facility.

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14. EMERGENCY MANAGEMENT

Duke Cogema Stone & Webster has submitted under separate cover to the U.S. Nuclear Regulatory Commission an evaluation showing that the maximum dose to a member of the public offsite due to a release of radioactive materials will not exceed 1 rem effective dose equivalent, or an intake of 2 milligrams of soluble uranium. Therefore, in accordance with Title 10 of the Code of Federal Regulations §70.22(i)(1)(i), an Emergency Plan is not required to be submitted.

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15. MANAGEMENT MEASURES

Duke Cogema Stone & Webster (DCS) has established an administrative and programmatic framework to ensure that facility systems, structures, and components are available and reliable to perform their function when needed, and that work is conducted efficiently and in a manner that protects workers, the public, and the environment. This framework includes configuration management, maintenance, training and qualification, procedures, audits and assessments, incident investigations, and records management. Within this framework are the administrative and programmatic measures implemented for Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) items relied on for safety (IROFS) to ensure safety. This chapter describes the management measures implemented for MFFF IROFS. These management measures are implemented in accordance with a quality assurance (QA) program established in accordance with Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix B.

This chapter makes frequent reference to the DCS QA program described in the MOX Project Quality Assurance Plan (MPQAP), because management measures are closely related to quality assurance requirements. The MPQAP has previously been approved by the U.S. Nuclear Regulatory Commission (NRC).

15.1 QUALITY ASSURANCE

DCS implements the QA program described in the MPQAP. As noted above, the MPQAP has been approved by the NRC. A change that would reduce the commitments of the NRC approved QA program is submitted with written justification to the NRC for acceptance, prior to implementation by DCS. DCS implements the requirements of 10 CFR Part 21, *Reporting of Defects and Noncompliance,* for design, construction, procurement, testing, and operations of Quality Level 1 structures, systems, and components (SSCs) (i.e., IROFS SSCs). MPQAP Section 4, *Procurement Document Control*, requires that 10 CFR Part 21 be invoked for procurements of IROFS, unless the procurement is for a Commercial Grade Item.

15.2 CONFIGURATION MANAGEMENT

15.2.1 Configuration Management Policy

DCS implements configuration management (CM) processes to maintain effective control of the MFFF as-designed and as-built arrangement and operation. This provides reasonable assurance that IROFS safety functions are properly controlled, and that changes to the facility are properly addressed, evaluated, and approved, so as not to inadvertently create an unanalyzed condition.

15.2.2 Implementation of Configuration Management

Configuration management is implemented as an essential part of the design control process meeting the requirements of MPQAP Section 3, *Design Control*. The engineering function generates design documents according to approved procedures that meet the requirements of MPQAP Section 5, *Instructions, Procedures, and Drawings,* and MPQAP Section 3, *Design Control*. Design documents are distributed for use according to the requirements of MPQAP Section 6, *Document Control*. Completed design documents are maintained in the records

management system according to the requirements of MPQAP Section 17, *Quality Assurance Records*. Configuration control of installed SSCs, for example, is assured through MPQAP Sections 7 and 8, *Control of Purchased Material, Equipment, and Services,* and *Identification and Control of Materials, Parts, and Components*, respectively. Audits of the CM program are performed in accordance with MPQAP Section 18, *Audits*. Configuration management processes maintain the design requirements, the design basis documentation, and the facility to as-designed and evaluated-for-safety conditions. Changes to the MFFF are documented, reviewed, and processed in accordance with the requirements of 10 CFR §70.72, as described in Section 5.1.4.

15.2.3 Organization

The MFFF organization is described in Chapter 4. The plant manager is responsible for ensuring the overall successful implementation of the CM program. This includes development and approval of plans and policies necessary to provide overall program direction within DCS, including identification of management expectations.

The production function has primary responsibilities for the performance of CM program requirements.

15.2.4 Scope of CM Program

The DCS CM program applies to SSCs and associated documentation whose alteration or modification could affect the facility's licensed design or operation.

Configuration management requirements are implemented through use of procedures and other DCS implementing documents as described in Section 15.5.

15.2.5 Training

Personnel training requirements are described in Section 15.4.

15.2.6 Change Control

Configuration change control manages changes to approved documents and also is used to manage changes to physical and operational configurations.

15.2.6.1 Identification of Changes

Proposed changes that can lead to a temporary or permanent change in design requirements or physical configuration are identified. These changes may result in document changes, facility modifications, maintenance changes, or operational changes. Changes to documents controlled under the DCS CM program are described adequately to support technical reviews, management reviews, and approvals. Design changes are initiated and processed in accordance with procedures.

Documents included in the CM program are subject to an approval process that includes revision control. Original issue and revisions to documents in the CM program are approved and

controlled in accordance with procedures that address design control. DCS documents prepared by organizations other than the engineering function that are included in the CM program are also subjected to an approval process that includes a revision control process.

15.2.6.2 Review and Approval of Changes

The DCS CM program requires that changes to documents included in the CM program receive an evaluation and approval of the change prior to implementation. A technical review allows for evaluation of safety, environmental, and operational impacts of the change, as well as the identification of affected SSCs and facility documentation. Management review of changes considers design, performance, cost and schedule, compliance with safety requirements, operational effectiveness, logistics support, environmental requirements, and training.

15.2.6.3 Implementation of Changes

Proper identification of procedures and organizational interfaces are major elements of configuration management during the change process. To validate that changes meet the acceptance criteria and are compliant with the design requirements, verification of change implementation is a requirement of configuration control.

15.2.7 Document Control

15.2.7.1 Storage of Documents

Approved documents included in the CM program are stored in the DCS electronic data management system (EDMS). The EDMS is a tool capable of reporting the status of documents. Records not suitable for storage in this system are stored in conjunction with dual storage provisions and maintained as hard copy.

15.2.7.2 Identification of Documents

Capabilities to track and retrieve current documents included in the CM program, historical records, and other information by multiple attributes (e.g., document number, document subject, component number, component name, status, etc.) are accomplished in accordance with approved procedures.

To ensure uniformity in the DCS CM program, the MFFF document control function has the following responsibilities as they relate to configuration management:

- Receipt, electronic filing, and controlled release and distribution of approved documents
- Development of reports to identify approved documents, including those documents released for construction, procurement, or fabrication
- Documents supplied by other, external sources (e.g., vendor or supplier documentation, design input documents) are identified and included in the CM program.

15.2.8 Audits and Assessments

Audits and assessments are used to help define facility configuration management needs and to measure the implementation of the basic relationships between design requirements, physical configuration, and the operational configuration information. Compliance with CM requirements is then verified through QA audits and assessments as described in the MPQAP Section 18, *Audits*.

15.3 MAINTENANCE

DCS implements a Maintenance Program that includes provisions for planned, scheduled, and unplanned maintenance to ensure MFFF equipment will be available and reliable to perform their designed functions in accordance with the integrated safety analysis (ISA).

The Maintenance Program uses a graded approach to maintenance of MFFF equipment where the level of maintenance applied is commensurate with the importance of the equipment and functions. The two categories of MFFF equipment are IROFS and non-IROFS.

Maintenance for IROFS is developed and conducted to maximize availability and reliability for assurance that the designed safety functions and ISA requirements will be achieved, when needed. This maintenance is performed under strict procedural controls and the resultant records are maintained as proof of compliance to safety requirements.

Non-IROFS equipment will be maintained commensurate with designed functions. In general, non-IROFS maintenance will be performed to standard industrial practices. Maintenance is developed using information from such sources as equipment suppliers, reference plants, lessons learned from other appropriate facilities, etc.

The following sections describe the primary elements of the MFFF maintenance program.

The maintenance function is responsible for implementing the maintenance program, working closely with operations. A work management group is used to plan, schedule, coordinate, track work activities through completion, and maintain the associated records for analysis and trending of equipment performance and conditions. This information is assessed for indications of areas for adjustments and improvements to methods and frequencies. Should an incident investigation be initiated in accordance with the MFFF Incident Investigation Program, recommendations and corrective actions identified are assessed by the work management group and applied to the respective portions of the Maintenance Program.

Procedures used to perform maintenance use the applicable requirements of the design and safety analysis documents and meet the requirements of MPQAP Section 5, Instructions, Procedures, and Drawings. Where applicable, grading of QA controls is performed in accordance with requirements of MPQAP Section 2.2, Graded Quality Assurance. Spare and replacement parts are procured, received, accepted, stored, and issued according to the requirements of MPQAP Section 4, Procurement Document Control, Section 7, Control of Purchased Material, Section 8, Identification and Control of Materials, Parts, and Components, and Section 13, Handling, Storage, and Shipping. Required special processes are performed to meet the requirements of

MPQAP Section 9, Control of Special Processes. Equipment used to measure and record maintenance and inspection parameters is calibrated in accordance with the requirements of MPQAP Section 12, Control of Measuring and Test Equipment. Nondestructive examination, inspection, and test personnel are qualified and certified in accordance with MPQAP Section 2.5, Qualification/Certification of Nondestructive Examination (NDE) Personnel, and MPQAP Section 2.6, Qualification/Certification of Inspection and Test Personnel, respectively. Inspections are performed to meet the requirements of MPQAP Section 10, Inspection, and testing required after maintenance conforms to the requirements of MPQAP Section 11, Test Control. Maintenance activities meet the requirements of MPQAP Section 14, Inspection, Test, and Operating Status. Completed records of maintenance are maintained in the records management system, which meets the requirements of MPQAP Section 17, Quality Assurance Records.

15.3.1 Maintenance Elements

Maintenance activities generally fall into the following categories:

- Surveillance
- Preventive maintenance
- Corrective maintenance
- Functional tests.

These maintenance categories are discussed in the following sections.

15.3.1.1 Surveillance

Surveillances are planned and scheduled systematic procedures conducted at required intervals to monitor the performance of IROFS equipment for assurances they continue to meet their performance specifications, including availability and reliability goals. Surveillances may consist of measurements, inspections, functional tests, calibration checks, etc. The results of surveillances are monitored, and when degradation appears, appropriate corrective action is taken, which may include adjustments to the surveillance or preventive maintenance methods and frequencies.

Surveillance procedures prescribe compensatory measures, when required, that are applied during the performance of the surveillance activities.

15.3.1.2 Preventive Maintenance

Preventive maintenance activities are preplanned and scheduled for performance with approved procedures at specified time intervals. Preventive maintenance may include refurbishment, partial or complete overhaul, inspections, instrument calibrations, etc., to ensure the equipment's designed functions, which include availability and reliability goals, will respond as designed. Post maintenance functional tests are performed, as necessary, to confirm equipment functions have been restored to normal conditions.

15.3.1.3 Corrective Maintenance

Corrective maintenance is performed to repair or replace equipment that has unexpectedly degraded below performance requirements or failed. Due to the variety of degraded performance and failures possible, specific procedures may not exist for all possibilities. For this reason, the degraded condition or failure mechanism is evaluated to prescribe the appropriate maintenance procedures necessary to correct the problem, including compensatory measures that may apply during the performance of this maintenance. This maintenance then restores the faulted equipment to the required conditions necessary to perform the designed functions. Restored functions are confirmed with appropriate post maintenance functional tests. Corrective maintenance activities are performed with approved procedures in accordance with the QA program.

15.3.1.4 Functional Tests

In general, functional tests of equipment and controls are performed based on the extent of the maintenance activity to ensure that the disturbed functions have been properly restored to their designed and safety bases. Functional tests may be used as a surveillance technique, and are applicable to the corrective and preventive maintenance functions. Functional tests are conducted using approved procedures.

15.3.2 Work Control

Maintenance work, as described above, is performed through a coordinated and structured work control process that integrates with ongoing production activities and requirements and is managed by the work management group. The purpose of this structure is to minimize challenges to safety requirements, minimize challenges to production requirements, and maximize work efficiency. This work control process includes representation from functions, such as radiation protection and others, as necessary, for complete pre-planning of the required work. Work support functions coordinated include such items as work requests, procedures, schedules, radiation work permits, lockout/tagout requirements, etc.

15.3.3 Relationship of Maintenance Elements to Other Management Measures

The maintenance elements, as described above, interface with other management measures, for example:

- Configuration Management, for obtaining the current approved and controlled documents necessary to support the maintenance activity, such as drawings, specifications, and procedures
- Training and Qualification to ensure maintenance personnel are trained to perform their assigned tasks
- Plant Procedures for the applicable operating and maintenance procedures pertinent to support the maintenance activity.

15.4 TRAINING AND QUALIFICATION

Training and qualification of plant personnel is essential to the safe and successful design, construction, testing, and operation of the MFFF. Training of plant personnel is commensurate with the complexity of assigned tasks. Personnel are trained in the specific project and plant procedures identified by their supervisors as being needed for their assigned tasks. Training and retraining (e.g., to maintain proficiency or when changes to work methods, technology, or job responsibilities occur) meet the requirements of MPQAP paragraph 2.2.6, *Personnel Indoctrination, Training, and Qualification*. Training records are maintained in the records management system in accordance with the requirements of MPQAP Section 17, *Quality Assurance Records*.

15.4.1 Organization and Management of Training

Line managers are responsible for the content and effective conduct of training for their personnel. Training responsibilities for line managers are included in position descriptions, and line managers are given the authority to implement training for their personnel. The training function provides support to line managers by facilitating the planning, direction, development, conduct, evaluation, and control of a systematic performance-based training process, which may include a graded approach that fulfills job-related training needs.

Plant procedures establish the requirements for indoctrination and training of personnel performing activities relied on for safety. Exceptions from training requirements may be granted when justified and documented in accordance with the approved MFFF procedure.

Lesson plans are used for classroom and on-the-job training as required to assure consistent presentation of subject matter. When design changes or plant modifications are implemented, updates of applicable lesson plans are included in the change control process of the configuration management system.

Training records are maintained to support management information needs associated with personnel training, job performance, and qualifications.

15.4.2 Analysis and Identification of Functional Areas Requiring Training or Qualification

A needs/job analysis is performed and tasks identified to ensure that appropriate training is provided to personnel.

The training function consults with relevant subject matter experts, as necessary, to develop a list of tasks for which personnel training for specific jobs is appropriate. The list of tasks selected for training is reviewed and compared to the training materials as part of the systematic assessment of training effectiveness. The task list is also updated as necessitated by changes in procedures, processes, plant systems, equipment, or job scope.

15.4.3 Position Training Requirements

Minimum training requirements are developed for those positions whose activities are relied on for safety. Initial identification of job-specific training requirements is based on experience from

MELOX and La Hague, and United States facilities. Entry-level criteria (e.g., education, technical background, experience, and/or physical fitness requirements) for these positions are contained in position descriptions.

15.4.4 Basis for and Objectives of Training

Learning objectives identify the training content established by needs/job analyses and position-specific requirements. The task list from the needs/job analysis is used to develop action statements that describe the desired post-training performance. Objectives include the knowledge, skills, and abilities the trainee should demonstrate; the conditions under which required actions will take place; and the standards of performance the trainee should achieve upon completion of the training activity.

15.4.5 Organization of Instruction

Lesson plans are developed from learning objectives, which are based on job performance requirements. Lesson plans and other training guides are developed under guidance by the training function. Lesson plans are reviewed by the training function and, generally, by the organization responsible for the subject matter. Lesson plans are approved prior to issue or use.

15.4.6 Evaluation of Trainee Learning

Trainee mastery of learning objectives is evaluated through observation/demonstration, or oral or written tests. Such evaluations measure the trainee's skills and knowledge of job performance requirements.

15.4.7 Conduct of On-the-Job Training

In addition to appropriate classroom training, on-the-job training is used for IROFS activities when appropriate. On-the-job training is conducted by personnel who are competent in the technical aspects of the job being performed. Completion of on-the-job training is demonstrated by task performance, where feasible and appropriate. When the actual task cannot be performed in the work environment (e.g., conflicting plant operations), a simulation of the task is conducted, with the trainee explaining task actions in consideration of the conditions that would be encountered during actual performance of the task. This simulation ("walk-down") would use references, tools, and equipment appropriate for the actual task, to the extent practical.

15.4.8 Systematic Evaluation of Training Effectiveness

Under the direction of the training function, the training program is periodically and systematically evaluated to measure the program's effectiveness in producing competent employees. Trainees provide feedback after completing their classroom training as their evaluation for program improvements. These evaluations identify program strengths and weaknesses, determine if program content matches current job needs, and determine if corrective actions are needed to improve the program's effectiveness. The training function is responsible for leading the training program evaluations and for implementing corrective actions. Program evaluations may consist of an overall periodic evaluation, or a series of topical evaluations over a given period.

Evaluation objectives that are applicable to the training program or topical area being reviewed may address the following elements of training:

- Management and administration of training and qualification programs
- Development and qualification of the training staff
- Position training requirements
- Determination of training program content, including its facility change control interface with the configuration management system
- Design and development of training programs, including lesson plans
- Conduct of training
- Trainee examinations and evaluations
- Training program assessments and evaluations.

Evaluation results are documented, and noteworthy practices and weaknesses are highlighted in the training program. Identified deficiencies are reviewed, improvements are recommended, and changes are made to procedures, practices, or training materials, as necessary.

15.4.9 Personnel Qualification

The qualification requirements for technical personnel are determined as discussed in Section 15.4.2. Training and qualification requirements associated with quality-affecting activities are given in the MPQAP. Such requirements include QA training for project personnel, and qualification of nondestructive examination personnel, inspection and test personnel, personnel performing special processes, and auditors. Qualification requirements for key management positions are given in Chapter 4.

15.4.10 Provisions for Continuing Assurance

Personnel performing activities relied on for safety are evaluated at least every two years to verify that they continue to understand, recognize the importance of, and have the qualifications to perform their activities that are relied on for safety. The evaluation may be by written test, oral test, or on-the-job performance evaluation. The results of the evaluation are documented. When the results of the evaluation dictate, retraining or other appropriate action is provided. Retraining is also required due to plant modifications, procedure changes, and QA program changes that result in new or changed information.

15.5 PLANT PROCEDURES

This section describes the procedures used for control of overall facility operations, including IROFS. Activities involving special nuclear material (SNM) will be conducted in accordance with approved procedures. Management policies require strict adherence to procedures when performing work. In the event that a procedure cannot be executed as written, personnel are required to notify their supervisor. Stop-work authority within DCS is vested in each DCS employee, with respect to work within their scope of responsibility, whenever the health and

safety of workers, the public, or the environment is involved, or when continued work will produce results that are not in compliance with the DCS QA Program.

Plant procedures are developed and controlled under the requirements of the MPQAP. Specifically, the associated activities are implemented by personnel who are trained in accordance with the requirements of MPQAP Section 2, *Quality Assurance Program*. Plant maintenance, testing, and operating procedures meet the requirements of MPQAP Section 5, *Instructions, Procedures, and Drawings*. Plant procedures are distributed and otherwise controlled in accordance with the requirements of MPQAP Section 6, *Document Control*. When completed, procedure results (e.g., sign-offs, checklists, data sheets) are maintained in the records management system in accordance with the requirements of MPQAP Section 17, *Quality Assurance Records*.

15.5.1 Types of Procedures

Plant procedures are broadly categorized as either administrative procedures or operating procedures. Administrative procedures apply to functions or interfaces with other organizational functions. Operating procedures provide specific direction for functional task-based work. Operating procedures can apply DCS-wide or to a specific organization.

15.5.1.1 Administrative Procedures

Administrative procedures specify controls that apply to specific functions or interfaces with other organizational functions. They address administration and conduct of process activities in the following areas:

- Training and qualification
- Reporting
- Quality Assurance
- Equipment control (lockout/tagout)
- Shift turnover
- Work control
- Procedure management
- Nuclear criticality safety
- Fire safety
- Radiation protection
- Radioactive waste management
- Environmental protection
- Chemical process safety
- Calibration control.

15.5.1.2 Operating Procedures

Operating procedures provide specific direction for functional task-based work within an organizational function. Operating procedures include production, maintenance, and emergency

procedures. The results of the ISA are used to identify specific IROFS Administrative Controls that are developed.

Operating procedures include operating limits and controls, and specific IROFS Administrative Controls to ensure: nuclear criticality safety, chemical safety, fire protection, emergency planning, and environmental protection. If needed, safety checkpoints (e.g., hold points for radiological or criticality safety checks, QA verifications, independent operator verification) are identified at appropriate steps.

Operating procedures, with different types of documents, are organized to a consistent architecture, which include:

- Overall Operating Rules – These are general rules for production, maintenance, operational safety, security, emergency planning, and environmental protection.
- Unit Operating Instructions or Maintenance Instructions – These provide instructions for operating and maintaining process units or systems.

The scope of these procedures is as follows:

- Production procedures – startup, operation, shutdown, off-normal, alarm response, control of process and laboratory operations, and recovery after a process upset condition
- Maintenance procedures – preventive and corrective maintenance, repair, calibration, surveillance, and functional testing
- Emergency procedures – response to a criticality event, a hazardous chemical release, or an emergency external to the MFFF that may affect the MFFF.

15.5.1.2.1 Production Procedures

Production procedures control process operations and apply to utility, workstation, and control room operations identified in the MFFF ISA as IROFS.

Production procedures contain the following elements, as applicable:

- Purpose of the activity
- Policies and guidelines governing the procedure
- Type of procedure
- Steps for each operating process phase
- Normal operations
- Off-normal operations
- Temporary operations
- Emergency shutdown
- Emergency operations
- Normal shutdown
- Startup following an emergency or extended downtime
- Hazards and safety considerations

- Operating limits
- Precautions necessary to prevent exposure of hazardous chemicals or SNM
- Measures to be taken if contact or exposure occurs
- Safety controls and their functions that are associated with the process
- Specified time period or other limitations on the validity of the procedure.

15.5.1.2.2 Maintenance Procedures

Where appropriate, maintenance procedures include requirements for pre-maintenance activities involving reviews of the work to be performed, work controls, and reviews of procedures. Maintenance and work control procedures require clearance from the operations function to begin work, as well as notification when the work and associated post-maintenance functional testing are complete. Maintenance activities will be monitored/assessed in accordance with the MPQAP.

15.5.1.2.3 Emergency Procedures

Emergency procedures address the preplanned actions of operators and other plant personnel in response to an incident, criticality event, hazardous chemical release, or external emergency that may affect MFFF.

15.5.2 Preparation of Procedures

MFFF procedures are prepared using a consistent format, and are clear, concise and comprehensive in addressing the procedure subject. MFFF procedures are well organized, and may include (approved) checklists or data sheets as documented records of completion.

15.5.2.1 Identification and Preparation

The results of the ISA are used to identify specific operating and administrative procedures that are developed. Plant procedures are prepared by qualified individuals assigned by functional management responsible and accountable for the associated operation.

15.5.2.2 Review/Approval

Operating and administrative procedures are reviewed and approved by management responsible and accountable for the associated operation. The functional management may specify a review to be performed by another functional group. Prior to initial use, production and maintenance procedures are verified and validated.

15.5.2.3 Revisions

Procedure revisions, including temporary changes, are prepared and approved in the same manner as the original. Changes may be issued by revising the procedure, or by pen-and-ink change — in which case a change summary/approval form is appended to the procedure.

15.5.3 Use of Procedures

Compliance with operating and maintenance procedures is required, and operators and technicians are trained to report inadequate procedures or the inability to follow procedures. Dependent on the nature of the procedure and work location, procedures are either available at work stations, or are readily accessible where needed to perform work.

15.5.4 Control of Procedures

Following approval, plant procedures are processed for entry into the EDMS and issued for use. The MFFF training program, addressed in Section 15.4, ensures that necessary personnel are trained in the use of approved procedures before implementation.

Change control for operating and administrative procedures is the same as for other items in the document management system. Document management procedures ensure that changes to the facility, including procedures, are entered into the EDMS and address control and distribution of changes (including those for emergency conditions, temporary procedure changes, temporary modifications, etc.). The MPQAP provides requirements for QA procedures, which detail the controls for design input, processes, verification, changes, and approval.

To ensure technical accuracy, operating and maintenance procedures are reviewed every five years to verify their continued applicability and accuracy. Emergency procedures are reviewed annually for the first two years of MFFF operation and at least every two years thereafter. These periodic reviews are performed by qualified individuals assigned by the functional management responsible and accountable for the associated operation. Reissue/approval of a procedure, and incorporation of new and/or pen-and-ink changes, meet the requirements for procedure periodic review. Additionally, if procedural inadequacy is identified as a root cause from an incident investigation, applicable procedures are reviewed and modified, as necessary.

15.6 AUDITS AND ASSESSMENTS

DCS maintains the program for audits and assessments described in the MPQAP, Section 18, *Audits*.

15.7 INCIDENT INVESTIGATIONS

DCS implements two programs for investigating discrepancies: the Corrective Action Program and Incident Investigation Program. This section describes these programs.

15.7.1 Corrective Action Program

The MFFF Corrective Action Program is used for identifying, investigating, reporting, tracking, correcting, and preventing recurrence of conditions adverse to quality. It is performed in accordance with MPQAP Section 16, *Corrective Action*. Nonconforming materials, parts, or components are identified and controlled in accordance with MPQAP Section 15, *Nonconforming Materials, Parts, or Components*.

15.7.2 Incident Investigations

The MFFF Incident Investigation Program is used for investigating abnormal events, other than those that involve conditions adverse to quality identified in Section 15.7.1. Incident investigations are less formal than the Corrective Action Program. Identification of the need for an incident investigation may come from anyone in the MFFF organization. An incident investigation is performed by one or more individuals assigned by the manager of production. The process used for the investigation may be similar to that of the Corrective Action Program. Upon completion, a report on the incident and its investigation is made to the production manager, who initiates appropriate action(s), if determined necessary.

15.8 RECORDS MANAGEMENT

MFFF records are managed in accordance with the records management program described in MPQAP Section 17, *Quality Assurance Records.*