MFFFPEm Resource

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1.0 GENERAL INFORMATION

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1.1 Facility and Process Overview

1.1.1 Conduct of Review

This chapter of the Safety Evaluation Report (SER) discusses general information contained in Chapter 1 of the revised Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF or the facility) license application (LA) to possess and use radioactive material (MOX 2009). Chapter 1 of the MFFF LA provides general information about the facility processes and the site. It consists of a general facility description, material flow, and process overview. The objective of SER Chapter 1 is to familiarize the reader with the pertinent features of the proposed facility and the site.

1.1.1.1 *General Facility Description*

The facility will be a "plutonium processing and fuel fabrication plant," as defined in Title 10 *Code of Federal Regulations* (10 CFR), Section 70.4, "Definitions," of the 10 CFR 70.4. The facility is designed to convert surplus weapons-grade plutonium into MOX fuel that can be used to generate electricity at commercial nuclear power stations. The assemblies are composed of fuel rods which contain fuel pellets consisting of a blend of uranium and plutonium dioxides (PUO_2) (i.e., mixed oxides). The PUO_2 to be used would be obtained from weapons-grade plutonium inventories held by the U.S. Department of Energy (DOE), which are declared surplus to national security needs.

The MFFF is located in the F-Area of the DOE Savannah River Site (SRS) near Aiken, South Carolina (SC). The site encompasses approximately 0.17 km^2 (41 a), of which approximately 6.9×10^{-2} km^2 (17 acres (a)) will be developed with roads, facilities, or buildings. No roads, railroads, or waterways traverse the MFFF.

1.1.1.1.1 Controlled Area Boundary

With respect to the controlled area boundary (CAB), 10 CFR 70.61(f) requires that the applicant establish a controlled area, as defined in 10 CFR 20.1003, "Definitions." Section 20.1003 of 10 CFR defines the controlled area as "means 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 Shaw AREVA MOX Services (MOX Services or the applicant) control and that are a direct part of the MFFF. The CAB is coincident with the MFFF site boundary. The CAB is depicted in Figure 1.1.2-2 of the LA.

1.1.1.1.2 Facility Buildings and Structures

Facility buildings consist of the MOX fuel fabrication building, the emergency diesel generator building, the emergency fuel storage vault, safe haven buildings, the reagent processing building, the standby diesel generator building, the secured warehouse building, the administration building, and the technical support building. Miscellaneous site structures consist of a bulk gas storage pad; heating, ventilation, air-conditioning, and process chiller pads; diesel fuel filling stations; and other minor structures.

The main building is the MOX fuel fabrication building. This building will contain all of the PUO_2 handling, fuel processing, and fuel fabrication operations of the facility. It is a reinforced concrete building having a footprint of approximately 91.5 m (300 ft) by 137 m (450 ft) by approximately 22.3 m (73 ft) above grade. The building is composed of three major functional areas, (1) the MOX processing (MP) area, (2) the aqueous polishing (AP) area, and (3) the shipping and receiving area. In the AP area, PUO_2 feedstock received from either the pit disassembly and conversion facility (PDCF), or from alternate feedstock, would be processed to remove impurities, such as gallium and americium. The purified PUO_2 would then be blended with depleted uranium dioxide (UO_2) powder and processed into MOX fuel, and ultimately fuel assemblies, in the MP area. In the shipping and receiving area, plutonium and UO_2 would be received along with other materials necessary to produce fuel assemblies. Completed fuel assemblies would be shipped to commercial nuclear power plants from this area.

1.1.1.2 *Material Flow*

The facility would receive PUO_2 from the PDCF, to be located on the SRS near the facility, as well as other DOE sources (i.e., alternate feedstock). The material would be transported to the shipping and receiving area of the facility in approved shipping containers. The material would be unloaded and inspected according to the MFFF Material Control and Accounting (MC&A) and Radiation Protection Programs. The material would then be moved to the AP Area. The facility also would receive depleted UO_2 at the material receipt area of the secured warehouse building, where it would be inspected according to the MC&A and Radiation Protection Programs. The depleted UO_2 would be trucked to the shipping and receiving area of the facility. Fresh MOX fuel assemblies would be stored in the assembly storage vault in the facility before shipping offsite. For shipping to commercial power plants, the assemblies would be moved to the shipping and receiving area of the facility where they would be loaded into a MOX fresh fuel transportation package that had been approved by the U. S. Nuclear Regulatory Commission (NRC) in accordance with 10 CFR Part 71, and then loaded onto a secure transport vehicle for transport to commercial power plants for irradiation.

1.1.1.3 *Process Overview*

The facility would have two main process operations, (1) an AP process that serves to remove impurities, such as americium and gallium (i.e., polishing), and (2) the MP which converts the plutonium and depleted UO_2 into fuel pellets, fuel rods, and fuel assemblies. A summary of the major processes in the facility is provided below. A more detailed discussion of process chemistry and chemical safety is provided in Chapter 8 and Sections 11.1 and 11.2 of this SER.

1.1.1.3.1 Aqueous Polishing Process Overview

All feedstock, both from the PDCF and from other DOE sources, will be received as PUO_2. The PUO_2 received at the MFFF will contain small amounts of impurities that must be removed for use of the MOX fuel in reactors. Feedstock from the PDCF will contain impurities such as gallium, americium, and highly enriched uranium. The diversity of impurities and the level of impurities will be higher in alternate feedstock. Some of this alternate feedstock may have higher than normal salt contaminants (other than chlorides), some will contain chloride contaminants, and some will contain small amounts of uranium. The AP process is used to remove these impurities. The AP process consists of three major steps, (1) dissolution, (2) purification, and (3) conversion.

In the dissolution step, the PUO_2 powder received from the PDCF and other DOE sources would be placed into solution by electrolytic dissolution with silver in nitric acid. For AFS material containing chlorides, a dechlorinization process will be performed in the electrolyser prior to dissolution with silver in nitric acid.

The purification step involves purification of the plutonium solution in pulsed columns by solvent extraction. The solvent mixture would be tibutyl phosphate dissolved in hydrogenated polypropylene tertrame solvent. 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 valence state of the plutonium from +4 to +3 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 state is oxidized back to the +4 valence state by passing nitrous oxide fumes 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 in 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% tributylphosphate 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. Off gas from the rotary calciner is routed through High Efficiency Particulate Air filters prior to discharge to the atmosphere through the plant vent stack.

1.1.1.3.2 MOX Processing Overview

The purified PuO_2 powder would be used in the MP where it would be blended with depleted UO_2 powder to make MOX fuel. The MP process consists of four major steps, (1) powder blending, (2) pellet production, (3) rod production, and (4) fuel assembly production.

The first operation is the production of the powder master blend. Polished PuO_2 is mixed with Depleted UO_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 Depleted UO_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 pore-former 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 pore-former. The sintered pellets are ground to a specified diameter in center-less 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 MOX fuel assembly is subjected to a final inspection prior to shipment in a fresh fuel shipping cask.

1.1.2 Evaluation Findings

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The staff reviewed the facility and process overview from the applicant’s LA to possess and use radioactive material at the MFFF in accordance to Section 1.1 of NUREG-1718. The staff evaluated the facility and process overview descriptions provided by the applicant in Section 1.1 of the LA focusing on new or changed material when compared to the safety evaluation for the construction authorization (NRC, 2005).

The staff concluded that (1) the level of detail in the facility and process overview provided an adequate understanding of the facility and processes and conveyed the purpose of the facility; (2) the facility and the process overview appropriately cross-referenced material presented in later sections of the LA; and (3) the facility and process overview is consistent with, yet less detailed than, material in later sections of the application. As a result, the staff finds that the application meets the regulatory requirements of 10 CFR Part 70.22 and 70.65 for providing a facility and process overview for a license to possess and use radioactive material. More detailed facility and process descriptions are provided in other sections of the LA and are discussed in other chapters of this SER.

REFERENCES

(NRC, 2000) U.S. Nuclear Regulatory Commission, NUREG-1718, “Standard Review Plan for the Review of an Application for a Mixed Oxide Fuel Fabrication Facility,” Washington, DC, August 2000.

(NRC, 2005) U.S. Nuclear Regulatory Commission, 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.” Washington DC, March 2005

(MOX, 2009) Shaw AREVA MOX Services, “License Application,” Aiken, SC, October 2009.

10 CFR Part 20, “Standards for Protection Against Radiation”

10 CFR Part 70, “Domestic Licensing of Special Nuclear Material”

10 CFR Part 71, “Packaging and Transportation of Radioactive Material”

SECY-07-0047, “Staff Approach to Verifying the Closure of Inspections, Tests, Analyses, and Acceptance Criteria Through a Sample-Based Inspection Program,” dated May 16, 2007

1.2 Institutional Information

1.2.1 Conduct of Review

This chapter of the SER contains the staff’s review of institutional information described by the applicant in Chapter 1 of the LA. The staff used Chapter 1 in NUREG-1718, “Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility,” (NRC, 2000) as guidance in performing the review.

1.2.1.1 *Corporate Identity*

MOX Services is the applicant for the license to possess and use by-product material, source material, and special nuclear material (SNM). MOX Services is incorporated in the State of South Carolina as an LLC owned by Shaw Project Services Group, Inc. (SPSG), Shaw Environmental & Infrastructure, Inc. (SE&I), and AREVA, Inc.. These three companies are the equity owners of the LLC (SPSG 40%, SE&I 30%, and AREVA 30%). MOX Services 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.

1.2.1.2 *Foreign Ownership, Control, or Influence*

DOE is the owner of the MFFF, which is located at SRS in Aiken, SC. MOX Services is a South Carolina LLC, whose direct owners are all U.S. corporations. AREVA, Inc. (formerly COGEMA, Inc.), which owns a minority share of MOX Services (30%), is itself a wholly owned subsidiary of AREVA NC, a French company. SPSG and SE&I together hold a 70% majority interest in MOX Services. As a result, there is no direct foreign ownership, no foreign control, and no significant foreign interest in MOX Services. Furthermore, in awarding the contract to MOX Services 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 July 9, 1999, based on a Security Control Agreement between Shaw AREVA MOX Services, LLC and DOE, mitigating FOCI. Additionally, a favorable FOCI determination has been made for SE&I (30 September 2006, through reciprocity with the Department of Defense).

The NRC accepts DOE FOCI determinations based on a memorandum of understanding between the NRC and DOE dated October 9, 1996.

1.2.1.3 *Proposed License Information*

The applicant requested a license to receive, acquire, possess, use store, and transfer by-product material, source material, and SNM pursuant to 10 CFR Part 30, “Rules of General Applicability to Domestic Licensing of Byproduct Material”, 10 CFR Part 40, “Domestic Licensing of Source Material”, and 10 CFR Part 70 for the materials identified in Table 1.2-1.

Table 1.2.-1 BY-PRODUCT MATERIAL, SOURCE MATERIAL, AND SPECIAL NUCLEAR MATERIAL TYPE OF MATERIAL FORM OF MATERIAL POSSESSION LIMIT

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% 239Pu	Any chemical or physical form	15,000 kg Pu total*
MOX (mixture of UO2 and PuO2), with ≤ 22 wt% PuO2	Any chemical or physical form	400 kg Pu total 1,200 kg U total
MOX, with ≤ 6.3 wt% PuO2	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 235U
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	252Cf, 40 curies
By-product Material	Sealed Instrument Calibration Source	75Se, 40 curies
By-product Material	Sealed Instrument Calibration Source	239Pu, 1.3 microgram
By-product Material	Sealed Instrument Calibration Source	192Ir, 40 curies
By-product Material	Sealed Instrument Calibration Source	241Am, 370 Bq
By-product Material	Sealed Instrument Calibration Source	235U, 8000 Bq
By-product Material	Sealed Instrument Calibration Source	241Am, 400 millicuries
By-product Material	Sealed Instrument Calibration Source	137Cs, 10 microcuries

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

The term of the license that was requested is 20 years.

1.2.1.3.1 Regulatory Requirements to be Met Prior to Issuing a License to MOX Services for the MFFF

The regulatory requirements of 10 CFR 70.23(a)(8) states that an application for a license will be approved if the Commission determines that, where the proposed activity is the operation of a plutonium processing and fuel fabrication plant, construction of the principal systems, structures, and components (PSSCs) approved pursuant to 10 CFR 70.23(b) has been completed in accordance with the application. PSSCs are safety controls that are identified in the design bases as providing protection against the consequences of accidents or natural phenomena. A safety control is a system, device, or procedure intended to regulate a device, process, or human activity to maintain a safe state.

Thus in accordance with 10 CFR § 70.23(a)(8), the staff has determined that any license to possess and use SNM will not be issued, before a determination that construction of the PSSCs approved pursuant to section 70.23(b), is in accordance with the application.

The MFFF Construction Authorization Requests (CAR) lists the 53 PSSCs in Table 5.6-1 and their associated safety functions. The PSSCs are identified as administrative controls, active engineered controls or passive engineered controls. Since the NRC approval of the MFFF CAR on in March 2005 (NRC, 2005), the applicant has identified in the Integrated Safety Analysis (ISA) Summary associated with the LA, approximately ~~15,000~~12,000 Items Relied On for Safety (IROFS) designated to perform the design basis safety functions of the PSSCs.

The staff's findings as documented in the MFFF construction authorization, stated "in accordance with 10 CFR 70.23(b), on the basis of information described in the CAR, as revised, and the additional statements and commitments heretofore made by DCS (now called Shaw Areva MOX Services), the design bases of the PSSCs for the proposed MFFF and the quality assurance program, provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents", Additionally, the ISA Summary provides the IROFS for the facility that support the performance of the MFFF's safety functions. These IROFS perform the safety functions needed to satisfy the design bases defined in the CAR.

The verification of the construction of a PSSC will vary depending on the type and nature of the system, structure, or component. In some cases, a PSSC may be an administrative control (e.g., combustion loading controls), an active or passive engineering control, use of an approved item (e.g., 3013 transport cask approved under 10 CFR Part 71), or some combination of the above. Verification of PSSCs includes evaluations of procedures and of administrative and engineering IROFS. To support the verification, PSSCs that include items such as safety related inaccessible tanks in process cells will need to be verified prior to their entrapment.

As applicable to the specific type of PSSC, NRC construction inspection and/or the technical review programs will verify that the construction of each PSSC listed in Table 5.6-1 of the MFFF CAR has been completed and the design basis safety function can be met. It is expected that the IROFS related to a specific PSSC will range from one to several thousand.

Inspection of each IROFS is not required for providing reasonable assurance that construction of the PSSCs has been completed in accordance with the application. For this reason, the NRC has historically relied on a sample-based inspection program. One approach is for the staff to rely on a randomly selected set of samples for inspection. An alternative approach is to select a sample of inspection targets IROFS to determine if there is a reasonable basis for concluding that construction of the PSSCs has been successfully completed. The staff's chosen approach for a particular PSSC will be that which best fits the nature of the PSSC and can be practically performed.

The staff will prioritize potential IROFS for inspection considering the following attributes: (1) safety significance; (2) propensity for errors; (3) construction and testing experience; and (4) opportunity to verify by other means. A more detailed discussion of these attributes can be found in SECY-07-0047 (NRC, 2007), dated May 16, 2007. The NRC will focus its inspections on activities contributing to IROFS determined to have higher inspection value[1]. Similar to the definition in SECY-07-0047, it is not the IROFS that are prioritized, but rather the value of inspecting the IROFS to maximize the agency's ability to detect significant construction flaws. This inspection sample will include both observation of IROFS-related work at the MFFF construction site, vendor facilities, and review of calculations and analyses by the Office of Nuclear Material Safety and Safeguards (NMSS) technical staff. These inspection targets will define the minimum sample set the NRC will inspect. This will provide the staff with a comprehensive sample based on inspection and technical review for IROFS-related work.

It should be noted that some of the PSSCs described in the MFFF CAR have only one safety function and have only a few IROFS associated with that safety function. In that scenario, the inspection target sample size would be equal to the number of IROFS. The verification process will incorporate one or more of the following methods: (1) PSSC field inspection results; (2) technical staff reviews and evaluations; and (3) staff review of MOX Services PSSC completion bases. The inspections will include reviews of procedures, design verification and engineering reviews, vendor and procurement inspections, receipt inspections, installation inspections, reviews of testing and surveillance and maintenance inspections.

For each PSSC, the NRC will develop a verification plan to outline the inspection and technical review activities that will be performed in order to support the staff findings regarding 10 CFR 70.23 a(8). The NRC will certify that the verification of construction completion for all PSSCs subject to verification through inspection and technical review. The certification process is similar to that described in Inspection Procedure 94300 and will include the issuance of a PSSC construction completion memorandum following staff verification. This certification would indicate that there is reasonable assurance that the construction of each PSSC has been completed based on a comprehensive inspection verification process and include references to the relevant inspection reports. The NRC will file a notice advising the Atomic Safety and Licensing Board (if the record is still open) or the Commission (if the record is closed) once all information relevant to the verification of construction completion is before the agency.

1.2.2 <u>Evaluation Findings</u>

The staff evaluated the institutional information for approval to construct an MFFF at the SRS according to Section 1.2 of NUREG-1718 (NRC, 2000). The staff evaluated institutional information identifying the applicant's corporate structure, FOCI determinations, and proposed license possession limits in the license application focusing on new or changed material when compared to the safety evaluation of the construction authorization (NRC, 2005). The staff finds that the information is complete and accurate, is consistent with the recommendations in NUREG-1718 (NRC, 2000), and is, therefore, acceptable.

Based on the review, the staff concluded that the applicant meets the regulatory requirements in 10 CFR Part 70 for ownership, location, planned activities, and nuclear material to be handled in connection with the LA to possess and use radioactive material for the MFFF.

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[1] The term *higher inspection value* is defined in SECY-07-0047, "Staff Approach to Verifying the Closure of Inspections, Tests, Analyses, and Acceptance Criteria Through a Sample-Based Inspection Program," dated May 16, 2007.

REFERENCES

(NRC, 2000) NRC. NUREG-1718, “Standard Review Plan for the Review of an Application for a Mixed Oxide Fuel Fabrication Facility.” Washington, DC, 2000.

(NRC, 2005) U.S. Nuclear Regulatory Commission, 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.” Washington DC, March 2005

(MOX, 2008) Shaw AREVA MOX Services. “License Application”, October 2009.

(MOX, 2005) Duke Cogema Stone and Webster, “Construction Authorization Request”, March 2005.

(NRC,, 2007) SECY-07-0047, “Staff Approach to Verifying the Closure of Inspections, Tests, Analyses, and Acceptance Criteria Through a Sample-Based Inspection Program,” dated May 16, 2007