U.S. NUCLEAR REGULATORY COMMISSION

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SAFETY EVALUATION REPORT ON THE CONSTRUCTION AUTHORIZATION REQUEST FOR THE MIXED OXIDE FUEL FABRICATION FACILITY

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Docket No. 70-3098

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ACRONYMS

AC	alternating current
AEGL	Acute Exposure Guideline Level
ALARA	as low as reasonably achievable
ALI	allowable limit on intake
ALOHA	areal locations of hazardous atmospheres
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOA	area of applicability
AP	aqueous polishing
ARF	atmospheric release fraction
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BA	Bachelor of Arts
BDC	baseline design criteria
BMF	fuel fabrication building
BS	Bachelor of Science
BSH	Safe Haven Buildings
BSR	Shipping and Receiving Area
CAAS	Criticality Accident Alarm System
CAR	Construction Authorization Request
CCU	criticality control unit
CEDC	committed effective dose equivalent
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CM	configuration management
CRT	cargo restraint transporter
CSE	criticality safety evaluation
DC	direct current
DCF	dose conversion factor
DCP	double contingency principle
DCS	Duke Cogema Stone & Webster
DOE	U.S. Department of Energy
DR	damage ratio
DSER	draft safety evaluation report
DU	depleted uranium
DUO_2	depleted uranium oxide
EALF	Energy of Average Lethargy causing Fission
EDMS	electronic data management system
EIS	Environmental Impact Statement
EMMH	external man-made hazard
ER	Environmental Report
ERPG	Emergency Response Planning Guidelines
ES&H	environmental, safety & health
FHA	Fire Hazards Analysis
FNMC	Fundamental Nuclear Material Control
FTS	fluid transport system
HA	hazards analysis
HAN	hydroxylamine nitrate
HAZOP	hazard and operability (analysis)
HD	high depressurization
HEPA	high efficiency particulate air
HEU	high enriched uranium
HFE	human factors engineering
HSI	human-system interface
HVAC	heating, ventilation, and air conditioning
ICN	immediate control network
ICRP	International Commission on Radiation Protection
ICSBEP	International Handbook of Evaluated Criticality Safety Benchmark Experiments
IEEE	Institute of Electrical and Electronics Engineers
IROFS	items relied on for safety
I&C	Instrumentation and control
ISA	integrated safety analysis
JSHU	jar storage and handling unit
KDB	dissolution unit
KPA	purification uni
KWD	liquid waste reception unit
LFL	lower flammability limit
LIN	local industrial network
LPF	leak path factor
LWR	light water reactor
MAR	material-at-risk
MC&A	material control and accounting
MCC	motor control center
MDE	medium depressurization exhaust
MFFF	mixed oxide fuel fabrication facility
MFFP	MOX fresh fuel package
MMIS	manufacturing management and information system
MOX	mixed oxide
MP	mixed oxide process
MPQAP	MOX Project Quality Assurance Plan

NCS nuclear criticality control
NCSE nuclear criticality safety evaluation
NFPA National Fire Protection Association
NRC U.S. Nuclear Regulatory Commission
NPH natural phenomena hazards
MSDS Material Safety Data Sheet

PAG protective action guide
PBX public branch exchange
PC performance categories
PDCF pit disassembly and conversion facility

PEP personnel and equipment protection
PHA preliminary hazard analysis
PIP plutonium immobilization pit
PLC programmable logic controller
Pu plutonium
PuO_2 plutonium oxide
PUREX plutonium uranium reduction extraction
PSSCs principal structures, systems and components

QA quality assurance
QL quality level

RAI request for additional information
RF respirable fraction
RG regulatory guide

SA safety analysis
SAR safety analysis report
SCAPA DOE Subcommittee on Consequence Assessment and Protective Action
SRS Savannah River Site
SER safety evaluation report
SNM special nuclear material
SPDP Surplus Plutonium Disposition Program
SRP standard review plan (NUREG-1718)
SRS Savannah River Site
SSC structures, systems, and components
SST safe secure transport
STEL short-term exposure limit
SWB Secured Warehouse Building

TBP tributyl phosphate
TEDE Total Effective Dose Equivalent
TEEL Temporary Emergency Exposure Limit
TLV threshold limit value
TQ threshold quantities
TRU transuranic

UBC Uniform Building Code
UL Underwriters Laboratories
USL upper subcritical limit
UPS uninterruptible power supplies

VHD very high depressurization

WAC waste acceptance criteria

XTN X-terminal network

EXECUTIVE SUMMARY

On February 28, 2001, Duke Cogema Stone & Webster (DCS or the applicant) submitted to the U.S. Nuclear Regulatory Commission (NRC) a construction authorization request (CAR), pertaining to a proposed Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) on the U.S. Department of Energy's (DOE) Savannah River Site (SRS). The MFFF would be a key asset of DOE's Surplus Plutonium Disposition Program (SPDP), which is being implemented as a result of a bilateral agreement with the Russian Federation. The U.S. and the Russian Federation agreed that each would convert 37.5 U.S. tons (34 metric tons) of weapons-grade plutonium (declared excess to national security needs) into forms less usable in nuclear weapons. The SPDP would convert surplus U.S. weapons-grade plutonium into MOX fuel. The CAR contains general information about the applicant, financial information, and safety information about the proposed facility's ability to resist natural phenomena and consequences of potential accidents. In support of the CAR, DCS had previously submitted a Quality Assurance Plan, Revision 2 (dated January 29, 2001) and an Environmental Report (dated December 19, 2000).

Pursuant to 10 CFR Part 70, applicants wanting to construct a plutonium processing and fuel fabrication facility must obtain NRC approval before starting construction. The regulation governing construction, 10 CFR 70.23(b), states that NRC will approve construction of the principal structures, systems and components of a plutonium processing and fuel fabrication facility if the NRC finds that the design bases of the principal structures, systems, and components and the quality assurance program provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. The NRC staff documents its review and conclusions on the safety-related aspects of an application in a Safety Evaluation Report (SER). This draft SER (DSER) documents the staff's review and conclusions concerning the CAR and its supporting information. After the CAR was submitted to NRC, DCS informed NRC that it intends to make changes to the proposed facility as a result of programmatic changes announced by DOE. In implementing its SPDP, DOE recently decided not to pursue the immobilization option for the disposition of surplus weapons-grade plutonium and will instead convert all of this material into MOX fuel. This DOE decision will require design changes to the MFFF to accommodate material having impurities that were not included in the previous design. This DSER does not address any changes to the facility design bases made necessary by the DOE decision. NRC will issue a revised DSER at a future time after it has received and reviewed the supplemental CAR to be provided by DCS that will fully describe the MFFF design changes.

DESCRIPTION OF THE FACILITY

The MFFF that DCS proposes to build would receive depleted uranium (DU) oxide (DUO_2) and plutonium oxide (PuO_2), purify the plutonium oxide to remove impurities such as gallium and americium, fabricate MOX fuel consisting of uranium and plutonium oxides, assemble fuel rods and fabricate fuel assemblies. The completed fuel assemblies would be subsequently irradiated in commercial nuclear power plants authorized by the NRC to use MOX fuel. The design of the MFFF is based on aspects of the LaHague and Melox facilities in France.

The proposed site is in Area-F of DOE's SRS in southwest South Carolina near Aiken. The site is restricted and has few public roads. There are no unrestricted public roads in the vicinity of Area-F. A rail system connects to commercial rail lines outside SRS boundaries. Nearby, the principal body of water is the Savannah River, which forms the SRS's southwest boundary. The MFFF site encompasses approximately 80 acres (0.324 km^2), of which, approximately 17 acres (6.9×10^{-2} km^2)will be developed with roads, facilities, or buildings. No roads, railroads, or waterways traverse the MFFF site.

The main MFFF building would be the MOX fuel fabrication building. This building would contain all of the plutonium oxide handling, fuel processing, and fuel fabrication operations of the MFFF. Plans call for a reinforced concrete building having a footprint of approximately 300 feet (91.4 m) by 400 feet (121.9 m) by approximately 73 feet (22.3 m) above grade. The building would have three major functional areas as follows: the MOX processing area, the aqueous polishing (AP) area, and the shipping and receiving area. In the AP area, plutonium oxide (PuO_2) received from the pit disassembly and conversion facility (PDCF) (not under NRC jurisdiction) would be purified to remove impurities such as gallium and americium. Plans call for the PDCF to be located on the SRS near the MFFF. The material would be transported to the shipping and receiving area of the MFFF in approved shipping containers and would be unloaded and inspected according to the material control and account (MC&A) and radiation protection program. The MFFF would receive depleted uranium oxide (DUO_2) at the material receipt area of the secured warehouse building, where it is also inspected according to the MC&A and radiation protection program. The DUO_2 would be trucked to the shipping and receiving area of the MFFF as needed for processing. After leaving the AP area and entering the MOX processing (MP) area in the main processing building, the purified PuO_2 would then be blended with DU powder and processed into MOX fuel and, ultimately, fuel assemblies. Fresh MOX fuel assemblies would be stored in the assembly storage vault in the MFFF before shipping offsite. For shipping to the commercial power plants, the assemblies would be moved to the shipping and receiving area of the MFFF where they would be loaded into a MOX fresh fuel transportation package that has been approved by NRC, and then loaded onto a secure transport vehicle for transport to the commercial power plants for irradiation.

SAFETY OF THE FACILITY

Potential accidents evaluated by the applicant include loss of confinement, fire, load handling events, explosions, nuclear criticality, natural phenomena events, external man-made events, external exposure, and those related to chemical interactions. Natural phenomena hazards evaluated by the applicant include earthquakes, high wind, tornadoes and tornado-generated missiles, extreme temperatures, rain, snow, ice, lightning, and fires external to the facility. Excluding nuclear criticality events, for which a prevention strategy has been proposed by the applicant, the staff's evaluation of consequences of potential accidents concludes that the bounding mitigated doses for the site worker would be approximately 0.5 rem (.005 Sv) (total effective dose equivalent [TEDE]). The staff estimates that the dose to the site worker from a nuclear criticality event would be approximately 3 rem (.03 Sv) TEDE (see Chapter 9.0 in the DSER). Excluding nuclear criticality events, for which a prevention strategy has been proposed by the applicant, the staff's evaluation of consequences of potential accidents concludes that the bounding mitigated doses for the offsite public would be approximately .003 rem (3×10^{-5} Sv) TEDE due to a loss of confinement. The staff estimates that the dose to the offsite public from a nuclear criticality event would be approximately .02 rem (2×10^{-4} Sv) TEDE (see Chapter 10.0 in the DSER). These doses would meet the 10 CFR 70.61 performance requirements.

SUMMARY

In the DSER, the NRC staff concludes that DCS has not met all of the applicable requirements pertaining to construction of the facility. Based on that the staff's review of the CAR and supporting information provided by the applicant, the staff finds that, due to the open items discussed in the DSER, DCS has not met the Baseline Design Criteria (BDC) set forth in 10 CFR 70.64(a). Further, until the open items are closed, the staff cannot conclude, pursuant to 10 CFR 70.23(b), that the design bases of the PSSCs identified by the applicant will provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. A complete list of the items that the staff considers unresolved as a result of its review is provided in Appendix A. The open items are discussed in the relevant chapters of the DSER.

The DSER is a snapshot of the NRC staff's present positions, based on information received to date. The staff's review will continue, and the staff expects to issue a revised draft and a final safety evaluation report on construction of the facility after evaluating further information to be submitted by DCS.

INTRODUCTION

On February 28, 2001, Duke Cogema Stone and Webster (DCS or the applicant), a limited liability company, submitted a request to construct a Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF or the facility) on the U.S. Department of Energy's (DOE) Savannah River Site (SRS) in Aiken, South Carolina. In support of its request, DCS had previously submitted a Quality Assurance Plan, Revision 2 (dated January 29, 2001) and an Environmental Report (dated December 19, 2000).

The MFFF would be a key asset of DOE's Surplus Plutonium Disposition Program (SPDP), which is being implemented as a result of a bilateral agreement with the Russian Federation. Pursuant to this agreement, the U.S. and the Russian Federation would each dispose of 37.5 U.S. tons (34 metric tons) of weapons-grade plutonium that has been declared excess to national security needs. The SPDP would convert weapons-grade plutonium into MOX fuel and irradiate that fuel in commercial reactors. The resulting spent fuel would contain plutonium in a form less usable in nuclear weapons.

The MFFF would consist of three major functional areas: 1) shipping and receiving; 2) aqueous polishing where the plutonium oxide would be purified; and 3) MOX production where the fuel pellets, fuel rods, and fuel assemblies would be fabricated. The MFFF would receive depleted uranium (DU) oxide (DUO_2) and plutonium oxide (PuO_2), purify the plutonium oxide to remove impurities such as gallium and americium, fabricate MOX fuel, consisting of uranium and plutonium oxides, assemble fuel rods and fabricate fuel assemblies. The completed fuel assemblies would be subsequently irradiated in commercial nuclear power plants authorized by the NRC to use MOX fuel.

This draft safety evaluation report (DSER) documents the staff's review of the February 28, 2001 Construction Authorization Request (CAR) and supplemental supporting information provided by the applicant. This DSER only addresses regulatory requirements for approval of construction and does not address operational aspects of the facility.

Under the applicable 10 CFR Part 70 requirements, before an operating license may be issued, the NRC must first authorize construction of the MFFF. In this regard, 10 CFR 70.23(b) states that NRC will approve construction of a plutonium processing and fuel fabrication facility if it finds that the design bases of the principal structures, systems and components (PSSCs) and the quality assurance (QA) program provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. In each section of DSER, the staff makes either a preliminary or conditional 10 CFR 70.23(b) safety finding on the applicable PSSCs and design bases being evaluated, depending on the nature and extent of the relevant open items which have not been resolved.

Regarding the term "design bases," NRC stated in a letter to DCS dated October 26, 1999, that the design basis definition in 10 CFR 50.2 will be applied to the proposed MFFF. Section 50.2 of 10 CFR defines design basis as:

> Design basis means that information which identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific

values or range of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals.

Another 10 CFR Part 70 requirement applicable to authorizing construction of the MFFF is 10 CFR 70.64. Listed in 10 CFR 70.64(a) are baseline design criteria (BDC), which are a set of criteria covering ten design issues: (1) quality standards and records; (2) natural phenomena hazards; (3) fire protection; (4) internal environmental conditions and dynamic effects; (5) chemical protection; (6) emergency capability; (7) utility services; (8) inspection, testing and maintenance; (9) criticality control; and (10) instrumentation and controls. In DSER sections where one or more of the BDC are applicable, the staff states whether or not the MFFF preliminary design satisfies the BDC, pursuant to 10 CFR 70.64(a).

The staff's DSER describes how the BDC requirements for new facilities listed in 10 CFR 70.64(a), are satisfied by the design bases. The BDC specify design features that are required and acceptable under the conditions specified in 10 CFR 70.64(a). The BDC are consistent with risk-informed regulation, in that, for new facilities, NRC recognizes that certain minimum requirements be applied as design and safety considerations. The applicant, however, may use the license application to justify reduced criteria consistent the ISA summary for the final facility design. Reductions in applying the BDC, if approved by NRC in issuing an operating license to DCS, would also constitute compliance with 10 CFR 70.64(a).

Under 10 CFR 70.64(b), the MFFF design and layout must be based on defense-in-depth practices. As used in 10 CFR 70.64, defense-in-depth practices at new facilities means a design philosophy, applied from the outset and through completion of the design, that is based on providing successive levels of protection such that health and safety will not be wholly dependent upon any single element of the MFFF design. The net effect of incorporating defense-in-depth practices is a conservatively designed facility that will exhibit greater tolerance to failures and external challenges. In DSER Chapter 5, the staff discusses whether or not the MFFF preliminary design is properly based on defense-in-depth practices.

Section 70.64(b) of 10 CFR further requires that, to the extent practicable, the MFFF design must incorporate (1) a preference for engineered controls over administrative controls, to increase overall system reliability; and (2) features that will enhance safety by reducing challenges to items which will be relied upon for safety. In DSER Chapter 5, the staff discusses whether or not the MFFF preliminary design adequately incorporates a preference for engineered controls over administrative controls, and whether design features will adequately enhance safety.

In Section 5.5.5 of the CAR, the applicant describes its general design philosophy and defense-in-depth practices used in formulating the preliminary design of the MFFF. Pursuant to 10 CFR 70.64(b), in order to ensure that engineered controls are relied upon over administrative controls, to the extent practicable, DCS states it has established a hierarchy of controls. In further adherence to 10 CFR 70.64(b), DCS states it has incorporated defense-in-depth practices in its preliminary MFFF design. In Section 5.5.5.2 of the CAR, DCS states that it has incorporated defense-in-depth practices through use of the double contingency principle for protection against criticality events, and use of the single failure criterion. Under the latter criterion, DCS states that for the PSSCs it has identified, each is required to be capable of carrying out its function in the event any single active component fails, whether such failure occurs within the applicable system, or in an associated system that supports the component's operation. In Section 5.5.5.4 of the CAR, DCS states that the BDC are incorporated into the MFFF design. The staff evaluates these DCS statements in the DSER.

The other 10 CFR Part 70 requirement partially applicable to authorizing construction of the MFFF is 10 CFR 70.61. Pursuant to the 10 CFR 70.61(b-d) performance requirements, the risk of accidents must be limited. Section 70.61(b-c) of 10 CFR designates potential accidents as either credible high consequence events, or credible intermediate consequence events. Section 70.61(d) of 10 CFR sets forth a performance requirement pertaining specifically to criticality accidents. The starting point for the applicant's demonstration of acceptable control over the risk of such events occurring is the safety assessment of the design bases for the construction approval, which DSER Chapter 5 evaluates. Section 70.61(a) of 10 CFR references the integrated safety analysis (ISA). DCS is required to submit an ISA summary as part of its application for a 10 CFR Part 70 operating license. Section 70.61(e) of 10 CFR requires the establishment of controls, which the rule designates as "items relied on for safety" (IROFS). DCS shall later identify the IROFS for the MFFF as part of its application for a 10 CFR Part 70 operating license.

Although 10 CFR Part 70 also contains other requirements applicable to the review of operating license requests, only 10 CFR 70.23(b) and 10 CFR 70.64 wholly apply to the safety findings for constructing the MFFF.

The staff used NUREG-1718, "Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility" (SRP), published in August 2000, as guidance in performing its review of the CAR and its supporting information. The DSER discusses the applicant's selection of design basis functions and values and how the applicant determined that the design bases will provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents.

In the CAR, the applicant has evaluated PSSCs primarily at the systems level, and the identified PSSCs are primarily design features/administrative controls that are to be implemented in the final design as IROFS to meet the requirements of 10 CFR 70.61(e). The SRP defines PSSCs as "safety controls that are identified in the design bases as providing protection against the consequences of accidents or natural phenomena. Designating a control as a PSSC is effectively synonymous with designating that control as an IROFS." The definition of IROFS in 10 CFR 70.4 states in relevant part that IROFS are "structures, systems, equipment, components, and activities of personnel that are relied on to prevent potential accidents at a facility that could exceed the performance requirements in [10 CFR] 70.61 or to mitigate their potential consequences." As stated in the 10 CFR Part 70 Subpart H rulemaking (Reference I.1), IROFS may be described at the systems level, provided that there is enough detail to understand the function of the system in relation to the performance requirements. Accordingly, as discussed in the DSER chapters below, the staff finds it acceptable to identify PSSCs at the systems level. DSER Table 5-1 summarizes each PSSC identified by DCS, the safety functions of each PSSC, and the design bases associated with the PSSCs.

Management measures, as defined in 10 CFR 70.4, will be applied to IROFS to assure that they are available and reliable to perform their functions when needed. The ISA summary, the IROFS identified therein, and management measures will be evaluated when the staff reviews the license application. Note that even though the staff will review management measures at the operations phase, a limited review of management measures was performed in evaluating the CAR. The review is discussed in DSER Chapter 15.0.

REFERENCE

Federal Register Notice, Vol. 65, No. 181, September 18, 2000; FRN 56213