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**OAK RIDGE
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LABORATORY**



**Safeguards and Security
Considerations Associated
with the Use of Mixed-Oxide
Fuel in U.S. Commercial
Reactors**

M. E. Ehinger

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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**SAFEGUARDS AND SECURITY CONSIDERATIONS
ASSOCIATED WITH THE USE OF MIXED-OXIDE
FUEL IN U.S. COMMERCIAL REACTORS**

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National Security Program Office
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PREFACE

This document is one in a series of topical reports written in support of the U.S. Department of Energy's (DOE's) *Program Acquisition Strategy for Obtaining Mixed-Oxide Fuel Fabrication and Reactor Irradiation Services* (PAS) [formerly *Procurement Implementation Plan for Acquisition of Mixed-Oxide Fuel Fabrication Services and Reactor Irradiation Services* (PIP)]. This series of topical reports is intended to increase access to available information for parties interested in responding to PAS and the subsequent request for proposal. These topical reports address subjects relevant to DOE's strategy concerning disposition of surplus plutonium by irradiating mixed-oxide (MOX) fuel in existing, domestic commercial reactors. This report addresses safeguards and security issues relevant to MOX fuel use in these reactors. Requirements for the MOX fuel fabrication facility are discussed in a separate topical report. Transportation of materials between facilities is discussed in both reports. Although significant useful information is given in this report, a large body of other useful information is available from the various citations given.

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SAFEGUARDS AND SECURITY CONSIDERATIONS ASSOCIATED WITH THE USE OF MIXED-OXIDE FUEL IN U.S. COMMERCIAL REACTORS

M. E. Ehinger

ABSTRACT

The U.S. Department of Energy's overall plutonium disposition strategy includes irradiation of mixed-oxide (MOX) fuel derived from surplus weapons-usable plutonium via domestic, commercial reactors. The storage, handling, and irradiation of weapons-usable plutonium-derived MOX fuel will increase the requirements for safeguards and security at commercial light-water reactor sites, which presently only use low-enriched uranium fuel. Applicable safeguards and security regulations and requirements for the reactor irradiation services portion of the project are discussed in this topical report. Requirements for the MOX fuel fabrication portion of the project are discussed in a separate report.

1. BACKGROUND

1.1 GENERAL CONSIDERATIONS

According to the January 14, 1997, Record of Decision,¹ the U.S. Department of Energy's (DOE's) overall plutonium disposition strategy includes irradiation of mixed-oxide (MOX) fuel derived from surplus weapons-usable plutonium via domestic, commercial light-water reactors (LWRs). The MOX option for disposal of excess weapons plutonium involves manufacture of MOX fuel, transportation of the fuel to the reactor site, storage of fresh fuel at the reactor site, irradiating the MOX fuel elements, on-site storage of spent fuel, and finally transport and emplacement of the spent MOX fuel in a geological repository. The program acquisition strategy² limits consideration to the use of existing U.S. commercial reactors, all of which are LWRs that currently accept low-enriched uranium (LEU) fuel. Under the proposed plutonium disposition plan, the major difference (from current LEU fuel use) would be acceptance of MOX fuel, with the associated requirements for receipt verification measurements and storage prior to irradiation. Safeguards and security (S&S) requirements change significantly for use of highly enriched uranium (HEU) (>20% ²³⁵U) and plutonium. Fresh MOX fuel falls into this latter category. However, once sufficiently irradiated in a reactor, the MOX fuel would be under the same requirements as LEU fuel. Responses to the request for proposals (RFPs) should address the need to meet S&S requirements of MOX fuel in reactor operations.

The United States is a signatory of the Nuclear Non-Proliferation Treaty (NPT). The U.S. responsibilities under the NPT are set down in INFCIRC-153, which establishes responsibilities of the United States, as a nuclear weapons state, to allow inspection of nuclear activities by the International Atomic Energy Agency (IAEA). Under INFCIRC-153, there are provisions to exempt weapons activities of national security interest from inspection. However, some stored weapons material declared excess to national security interests has been placed under IAEA safeguards. The subject material for plutonium disposition will also be placed under IAEA safeguards as soon as practical. Thus, reactor operation activities would be subject to the rules and regulations for IAEA inspection under the provisions of INFCIRC-153 and the appropriate portion of Title 10 of the *Code of Federal Regulations* (CFR).

1.2 DOE vs NRC RULES

Operation of all nuclear facilities in the United States is strictly regulated. Operation of DOE facilities is regulated by a series of DOE orders. All commercial nuclear facilities within the United States operate

under license from the Nuclear Regulatory Commission (NRC) and are subject to the NRC regulations set down in 10 CFR. Both the DOE rules and the NRC rules are based on a graded approach to safeguards. Under the graded approach, S&S measures become more strict with increasing attractiveness of the material. Plutonium and HEU are subject to the highest levels of S&S. All responses to the MOX option RFP must consider that commercial nuclear reactors and nuclear fuel-handling activities in the United States are subject to NRC regulations and requirements as detailed in 10 CFR (rather than the DOE rules) and are subject to the high-level S&S requirements.

1.3 MOX SAFEGUARDS LICENSING HISTORY

During the 1960s and early 1970s, experience was gained with MOX fuel fabrication and its use in LWRs in the United States. At this time, plutonium operations were conducted under provisional operating licenses issued by the U.S. Atomic Energy Commission (AEC). In 1974, there was a significant change in regulatory development. AEC was replaced by the Energy Research and Development Agency and NRC. Title 10 CFR emerged as the guiding requirement for commercial nuclear operations. Environmental regulations were evolving, and the concept of environmental impact analysis was emerging. At the time, there was still an active program to move toward nuclear fuel reprocessing and use of MOX fuel. A series of hearings was initiated related to the *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in Light-Water Cooled Reactors* (GESMO)³ to begin the process of licensing the use of MOX fuel under the emerging regulations. The process continued until 1977, when then-President Carter announced an executive decision to forego the use of plutonium in commercial reactors and canceled the GESMO hearings. The executive policy remained in effect until President Reagan officially lifted the ban on plutonium recycle in 1983. However, there was never an initiative to resume hearings on licensing of plutonium recycle.

2. LICENSING REQUIREMENTS—10 CFR PART 70

“Domestic Licensing of Special Nuclear Material,” 10 CFR Part 70, establishes the procedures and criteria to acquire, own, deliver, receive, possess, use, and initially transfer special nuclear material, and it establishes the terms and conditions upon which the NRC will issue such licenses. Also established are definitions that define the graded safeguards approach. Current fresh fuel storage facilities at reactor sites in the United States are licensed to handle and comply with the requirements for “special nuclear material of low strategic significance,” fitting the definition for fresh fuel that is enriched to less than 10% ²³⁵U and no plutonium as specified in 10 CFR Part 70.4. By the definitions in 10 CFR 70.4, the fresh fuel stores for MOX fuel would have to comply with the requirements for “strategic special nuclear material of high strategic significance.” Responses to the RFP must consider the requirement to comply with provisions for licensing under 10 CFR 70.4.

Operating LWRs in the United States comply with requirements for use and handling of LEU fuel under their existing licenses. No LWRs are currently licensed for MOX fuel, and the rules for licensing of MOX fuel do not yet exist. Thus, the application procedure for the licence amendment to handle MOX fuel in an LWR would be similar to filing the license application to handle formula quantities (defined in 10 CFR 70.4) of strategic nuclear materials in accordance with 10 CFR Part 70.21. This part addresses facilities that process HEU and/or plutonium. The licensing process includes requirements for measurement and control of nuclear material. The RFP respondents should consider that requirements for handling nuclear material of high strategic significance will be applicable to receipt and storage of fresh MOX fuel. Title 10 CFR Parts 70.52, 53, and 54 describe the reporting requirements; Part 70.57 establishes the requirements for measurement control programs for material of strategic significance. These requirements go well beyond those for typical LEU fuel. While the rules do not currently address the use of MOX fuel, the RFP respondents should address these requirements for receipt measurements and inventory verification on storage of fresh MOX fuel. Part 70.58 presents the elements that should be addressed in the material accounting plan required as part of the licensing submission for reprocessing facilities and facilities that handle “special nuclear materials of moderate strategic significance in a quantity exceeding one effective

kilogram.” The RFP responses should also address the need to meet these requirements for the LWR MOX fuel storage areas.

3. MATERIAL CONTROL AND ACCOUNTABILITY REQUIREMENTS—10 CFR PART 74

Because DOE has committed to be responsible for transport of fresh MOX fuel to the reactor site, control and accountability in accordance with 10 CFR 74 will not be applied by the private sector until the fresh MOX fuel is received at the site. All requirements for control, accountability, and physical protection should be applied upon transfer of custody.

Title 10 CFR Part 74 contains the requirements for material control and accounting of special nuclear material. As stated in 10 CFR Part 74.1(a), “This part has been established to contain the requirements for the control and accounting of special nuclear material at fixed sites and for documenting the transfer of special nuclear materials.” Current reactor operations are under general requirements of 10 CFR Part 74.31, which requires a program to maintain current knowledge on both the location and movement of the material, requirements to report on movements, and requirements for periodic inventories of the material.

Subpart E of 10 CFR Part 74, “Formula Quantities of Strategic Special Nuclear Material,” generally addresses process facilities that handle strategic nuclear materials that require extensive safeguards measures such as process monitoring. Reactor operations involving MOX fuel would have to address the requirements for item monitoring set down in 10 CFR Part 74.55 and would have to include procedures for alarm resolution addressed in 10 CFR Part 74.57. There would be elements associated with quality assurance and accounting requirements of 10 CFR Part 74.59 associated with receipt and inventory measurements of MOX fuel. The RFP responses should address commitments to comply with these requirements.

4. PHYSICAL PROTECTION REQUIREMENTS—10 CFR PART 73

Physical protection requirements for fixed sites start with understanding the definitions in 10 CFR Part 70.4. Reactor operations are subject to the requirements of 10 CFR Part 73, “Physical Protection of Plants and Materials.” The general requirements address the need to protect against theft and sabotage. Fresh MOX fuel at reactor sites would also be subject to additional physical security requirements as described in 10 CFR Part 73.60. These requirements include vault storage and access control, which may require redesign of existing facilities to accommodate MOX fuel. S&S requirements for spent fuel would be the same for MOX fuel as for LEU fuel. Title 10 CFR 73 addresses physical security requirements for SNM and describes relaxed requirements in 10 CFR 67 for physical protection of SNM of moderate to low strategic significance. The RFP responses should include a commitment to meet the additional physical security requirements for strategic nuclear materials as described in this section.

5. INTERNATIONAL SAFEGUARDS REQUIREMENTS

Title 10 CFR 73 describes the physical protection requirements for international transport of special nuclear materials (SNM). Notification to the appropriate authorities of the intent to conduct transport of SNM to a shore facility for further delivery to an international facility would bring these requirements into use.

By provisions of INFCIRC-153, the United States provides a list of eligible domestic facilities from which the IAEA can select facilities for inspection. This is the method by which the United States and the other weapons states can exclude facilities of national security interest from inspection, but submit fuel cycle facilities to international safeguards. The United States has made a commitment to subject excess weapons material to IAEA safeguards. Several storage sites for excess weapons material have been placed

under inspection. With material disposition, the facilities involved can be expected to be placed on the eligibility list.

Title 10 CFR Part 75 describes the U.S. voluntary safeguards offer under INFCIRC-153. This part describes the process by which facilities are placed on the eligibility list and the process that is initiated when the facility is selected for inspection. Selection requires submission of information describing the facilities and nuclear material control procedures to allow the IAEA to develop an inspection plan. The provisions of 10 CFR Part 75 describe the facility obligations to provide information through the national nuclear material information system to the IAEA (to support inspections) and the requirements to accommodate inspections. It can be expected that the reactors involved in plutonium disposition will be offered and selected from the eligibility list. The RFP responses should include commitment to comply with provisions of 10 CFR Part 75 to accommodate IAEA inspection.

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1. *Record of Decision for the Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*, U.S. Department of Energy, Office of Fissile Materials Disposition, January 14, 1997.
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3. *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in Light-Water Cooled Reactors*, NUREG-0002, U.S. Nuclear Regulatory Commission, August 1976.

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