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Regulatory Considerations for Domestic Reprocessing Facility Physical Security

Nuclear Fuel Cycle and Supply Chain

Prepared for
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ABSTRACT

U.S. advanced non-light-water reactor vendors may pursue collocated on-site reprocessing activities. Therefore, these facilities are likely to possess formula quantities, or Category I quantities, of special nuclear material (SNM) during normal operations. The U.S. Nuclear Regulatory Commission (U.S. NRC) has yet to formally establish a regulatory framework for commercial reprocessing. While Category I requirements would explicitly not apply in this circumstance under current regulatory requirements, regulatory certainty does not exist. A novel framework should be developed to ensure public health and safety while also risk-informing the physical security requirements. This report reviews the relevant background of related rulemaking activities and proposes risk-informed physical protection requirements to satisfy these objectives.

Insights from NRC security-related rulemaking activities provide a substantial technical basis to approach potential establishment of physical security requirements for reprocessing facilities. If a licensee can provide justification that the material satisfies a sufficient self-protecting radiation dose threshold, the material may not be subject to theft or diversion requirements and only potential sabotage requirements would apply. Furthermore, if the material can be justified to be moderately dilute, a set of risk-informed requirements could provide adequate protection of public health and safety. A revised performance objective for prevention of theft of moderately dilute Category I SNM may be detection to allow prompt recovery by a local law enforcement agency.

However, a significant caveat to the proposed categorization scheme is the unknown integration of radiological sabotage with requirements for the protection against theft. Future licensees should consult with the NRC regarding treatment of this regulatory topic. Additionally, the self-protecting radiation dose threshold (either the existing or a proposed future threshold) would need to be considered. An integrated approach may apply graded potential requirements for protection against the design basis threat of radiological sabotage currently applicable to commercial nuclear power plants and Category I SNM facilities defined within 10 CFR 73.1(a).

CONTENTS

TABLES

ACRONYMS

Abbreviation	Definition
AEA	Atomic Energy Act
CAS	Central Alarm Station
CFR	Code of Federal Regulations
COEX	Coextraction
DOE – NE	Department of Energy Office of Nuclear Energy
FoF	Force-on-Force
FOM	Figure of Merit
IND	Improvised Nuclear Device
LLEA	Local Law Enforcement Agency
MBA	Material Balance Area
MC&A	Material Control and Accountancy
MOU	Memorandum of Understanding (MOU)
MPACT	Materials Protection, Accounting, and Control Technologies
MWd/kg	megawatt-day per kilogram
NRC	Nuclear Regulatory Commission
Pu	Plutonium
SAS	Secondary Alarm Station
SNM	Special Nuclear Material
U	Uranium
VTR	Vault-Type Room

REGULATORY CONSIDERATIONS FOR DOMESTIC REPROCESSING FACILITY PHYSICAL SECURITY

1. Introduction

The United States Nuclear Regulatory Commission (U.S. NRC) regulates the civilian nuclear sector to promote the common defense and security and to ensure public health and safety.[1] The NRC implements requirements for licensees to implement physical security measures such as intrusion detection, delay barriers, and armed response personnel to protect against potential threats to civilian nuclear facilities. The NRC issues these regulatory requirements through Title 10 of the Code of Federal Regulations (10 CFR). The NRC issues security requirements for special nuclear material (SNM) based on the type and quantity of material present at a facility in a graded approach.[2] While the NRC has authority to regulate reprocessing facilities for commercial purposes through the Atomic Energy Act (AEA) of 1954, the NRC currently has no regulatory framework related to licensing a commercial reprocessing facility. This white paper builds upon a January 2025 material control & accountancy (MC&A) regulatory analysis from the U.S. Department of Energy's Office of Nuclear Energy (DOE-NE) Materials Protection Accounting and Control Technologies (MPACT) program to expand considerations for reprocessing facilities to physical protection.[3]

1.1 NRC Regulatory Framework for SNM

The current NRC framework places SNM into one of three categories based primarily on the risk of adversarial development of an improvised nuclear device (IND). The categories are outlined in 10 CFR Part 110, Appendix M, "Categorization of Nuclear Material," and are summarized below in Table 1.[4]

[1] U.S. Nuclear Regulatory Commission, "Backgrounder on Nuclear Security," Page Last Reviewed/Updated Thursday, December 05, 2024, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.html.
[2] Defined as "Plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235." U.S. Nuclear Regulatory Commission, "Special nuclear material," Page Last Reviewed/Updated Tuesday, March 09, 2021, https://www.nrc.gov/reading-rm/basic-ref/glossary/special-nuclear-material.html.
[3] "MC&A Considerations for U.S. Reprocessing Facilities," U.S. Department of Energy Materials Protection, Accounting, and Control Technologies, Philip Honnold and Audrey T. Nguyen, Sandia National Laboratories, January 2025, SAND2025-00766R.
[4] Appendix M to Part 110—Categorization of Nuclear Material, Page Last Reviewed/Updated Friday, April 17, 2020.

Table 1 – NRC SNM Categorization

Material	Form	Category I (Strategic Special Nuclear Material	Category II (Special Nuclear Material of Moderate Strategic Significance)	Category III (Special Nuclear Material of Low Strategic Significance)
Plutonium except that with >80% ^{238}Pu	Unirradiated[5]	≥ 2 kg	< 2kg but > 500 g	≤ 500 g but > 15 g
^{235}U	Unirradiated[5]			
	≥ 20% enrichment	≥ 5 kg	< 5 kg but > 1 kg	≤ 1 kg but > 15 g
	≥ 10% but < 20% enrichment			< 10 kg but > 1 kg
	Above natural but < 10% enrichment			≥ 10 kg
^{233}U	Unirradiated5	≥ 2 kg	< 2kg but > 500 g	≤ 500 g but > 15 g
Irradiated Fuel			Depleted or natural U, Th, or low-enriched fuel with < 10% fissile content[6]	

[5] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gray per hour (100 Rad per hour) at 1 m unshielded. (Appendix M to 10 CFR Part 110 – Categorization of Nuclear Material).

[6] Other fuel that by virtue of its original fissile material content is classified as Category I or II before irradiation may be reduced one category level while the radiation level from the fuel exceeds 1 Gray per hour (100 Rad per hour) at one meter unshielded. (Appendix M to 10 CFR Part 110 – Categorization of Nuclear Material).

1.2 NRC Reprocessing Rulemaking

In 2007 the NRC Commissioners asked the staff to execute a regulatory gap analysis of the 10 CFR regulatory framework for how a reprocessing facility may be licensed.[7] Under the current NRC SNM categorization scheme, Pu of a quantity greater than or equal to 2 kg with an associated radiation level less than one Gy per hour unshielded at one meter would be designated as Category I SNM. Category I SNM requirements are outlined in the general performance objectives in 10 CFR 73.20(a) to protect against the theft or diversion DBT defined in 73.1(a), and additional specific requirements are outlined in 73.45 through 73.46. Requirements for Category I SNM are generally much stricter than those for Category II and III SNM, such as for response and access authorization.

NRC Regulatory Guide (RG) 5.52, Revision 3, "Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites," provides guidance for what information applicants should include in the content of their physical protection plans of facilities holding formula quantities of SNM other than nuclear power plants. Multiple NUREGs provide guidance that may be useful for applicants of Category I fuel cycle facilities on physical security plans.[8]

However, 10 CFR Part 74.51 explicitly excludes reprocessing facilities from Category I MC&A requirements.[9] A May 2009 regulatory gap analysis in SECY-09-0082 stated that this exclusion should be removed to protect against theft and diversion of separated SNM.[10] In Gap 8 – "Risk Informing 10 CFR Part 73 and 10 CFR Part 74," a recommendation was made for incorporation of attractiveness levels in the existing NRC material categorization scheme in order to risk-inform the regulatory requirements. The analysis explained how Category I protection may not be necessary and may place an undue regulatory burden on reprocessing facilities. The staff proposed a new 10 CFR Part 7x to provide a performance-based approach and completed a draft regulatory basis for the proposed reprocessing facility rulemaking in November 2011.[11] The NRC staff suggested in the regulatory basis that risk-informing the physical protection and MC&A regime should rely on an associated rulemaking ongoing at the time, Material Categorization and Future Fuel Cycle Facility Security-Related Rulemaking SECY-09-0123. The Commission approved a revised categorization scheme but did not include reprocessing within this scheme and asked the staff to look at reprocessing in a separate but lower-priority rulemaking. However, due to a lack of apparent industry near-term interest in licensing reprocessing facilities, the proposed reprocessing regulatory framework rulemaking was terminated in 2021.

1.2.1 Insights from NRC Reprocessing Rulemaking

While the reprocessing rulemaking was discontinued and therefore no definitive regulatory clarity currently exists for domestic reprocessing facility security, several informative references were produced by NRC and associated organizations during the rulemaking process, which can potentially inform future technical bases for related licensing activities. Furthermore, the 2015 regulatory basis document for the Enhanced Security of Special Nuclear Material proposed rulemaking offers valuable insights that may inform the

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[7] U.S. Nuclear Regulatory Commission, "Reprocessing," Page Last Reviewed/Updated Monday, May 15, 2023, https://www.nrc.gov/materials/reprocessing.html.

[8] For example, NUREG-1322, "Acceptance Criteria for the Evaluation of Category I Fuel Cycle Facility Physical Security Plans", October1991, and NUREG-1456, "An Alternative Format for Category I Fuel Cycle Facility Physical Protection Plans", June 1992.

[9] U.S. Nuclear Regulatory Commission, Reprocessing Workshop, October 2010, Albuquerque, NM, https://www.nrc.gov/docs/ML1029/ML102980315.pdf.

[10] POLICY ISSUE, "Update on Reprocessing Regulatory Framework – Summary of Gap Analysis," May 28, 2009 SECY-09-0082, and Enclosure ML091520365 - SECY-09-0082 - Enclosure: Summary of Gap Analysis. (29 page(s), 5/28/2009).

[11] ML112081702 - SECY-11-0163 – "Enclosure: Draft Regulatory Basis for Licensing and Regulating Reprocessing Facilities," November 2011.

technical licensing bases of a variety of SNM fuel cycle facilities.[12] While this document was developed by the staff and did not receive any formal NRC Commission approval, the staff's proposals offer a starting point to develop a site's physical protection approach.

Category I SNM physical security requirements may be too rigorous for certain types of material at potential future reprocessing facilities. A risk-informed approach may logically follow a paradigm of requirements more similar to those of Category I SNM at non-power reactors that are protected against theft under 10 CFR 73.67(a) to (d) in addition to 73.60. If the material is not readily separable and meets the external radiation dose-rate threshold, the material is exempt from 73.60. In the NRC's 2015 regulatory basis for the Enhanced Security of Special Nuclear Material proposed rulemaking, the NRC concluded that the existing external dose rate would likely not be sufficient for use as a security feature because the adversary may not be incapacitated prior to completing the malicious act. A 2005 study by Oak Ridge National Laboratory concludes that a dose rate of 10,000 Rad (100 Gy) per hour would incapacitate an individual in approximately 30 minutes.[13] Alternatively, the requirements in 73.50 apply for Category I SNM that is not stored spent nuclear fuel or high-level radioactive waste subject to 73.51 and that satisfies the dose-rate exemption. In a reprocessing facility for aqueous or pyroprocessing, the product would likely be below the existing NRC self-protecting standard and therefore require dilution to justify lower levels of protection compared to existing requirements for Category I SNM.

1.3 Current Sabotage Framework

Requirements to protect against radiological sabotage may be warranted due to the potential consequences from dispersal of the material. The NRC's DBT of radiological sabotage defined in 10 CFR 73.1(a) is applicable to both nuclear power reactors and Category I SNM facilities. Physical security requirements for protection against sabotage of irradiated SNM of Category I quantities are included in 10 CFR 73.50. However, the NRC mentions that the risks of SNM use in a radiological dispersal device is a regulatory gap that the current regulatory framework does not adequately capture.[14] The NRC established protection requirements in 10 CFR Part 37 for Category 1 and 2 quantities of radioactive material to protect against a radiological dispersal device or radiological exposure device. The NRC also mentions that protection requirements in 10 CFR Part 37 for Pu isotopes other than ^{238}Pu and Pu/Be sources are also not addressed. Protection requirements for spent nuclear fuel from commercial light water reactors are found in 10 CFR 73.51 for spent fuel storage facilities and 10 CFR 73.55 for commercial nuclear power plants. The potential impacts of a necessary application of a blended approach of both sabotage and theft requirements are further discussed below.

2. Insights from DOE

DOE Standard 1194-2019 describes approaches for maintaining an MC&A program using a graded safeguards program.[15] The Standard describes material attractiveness levels and categorization to establish protection requirements commensurate with the "usefulness in constructing a weapon and/or an improvised nuclear device."[16] The Standard describes the range from Attractiveness Level A, representing materials directly usable in a weapon and/or IND, to Attractiveness Level E, representing materials requiring difficult

[12] U.S. NRC, Rulemaking for Enhanced Security of Special Nuclear Material, NRC Docket ID: NRC-2014-0118, Regulatory Basis Document, January 2015.

[13] COATES, C. et al, "Radiation Effects on Personnel Performance Capability and a Summary of Dose Levels for Spent Research Reactor Fuels", ORNL/TM-2005/261, December 2005.

[14] See NRC's 2015 regulatory basis for Enhanced Security of SNM, pp. 20-22.

[15] U.S. Department of Energy, DOE Standard, "Nuclear Materials Control and Accountability," DOE-STD-1194-2019, Washington, D.C., September 2019.

[16] DOE-STD-1194-2019, p. 23.

processing before potential use in a weapon and/or IND. The attractiveness levels are proposed as follows, directly quoted from the Standard:[17]

> *"Attractiveness Level A: Weapons and test devices; partially assembled weapons and test devices sufficient to construct an improvised nuclear device using commercially available parts and materials.*
>
> *Attractiveness Level B: Pure forms of SNM with a total SNM content exceeding 50 atom percent; that is, greater than half of the atoms present in the material shall be SNM. The SNM can be used in its existing form, or that can be utilized after simple mechanical removal of cladding, packaging, or matrix material to produce a weapon/improvised nuclear device through casting, forming, or other nonchemical operations.*
>
> *Attractiveness Level C: High-grade SNM that can be easily converted to metal. Generally, these materials are of high purity and require relatively little processing time or effort to obtain Level B material.*
>
> *Attractiveness Level D: Low-grade SNM that are more dilute or of lower purity than Level C materials, and require greater processing time or greater processing complexity to convert to metal than Level C materials.*
>
> *Attractiveness Level E: All accountable nuclear materials that do not meet the criteria for Attractiveness Level A through D."*

DOE requires graded control measures to implement control and accountability measures at a level commensurate with the potential consequences of loss of control of the material. The DOE Standard 1194-2019 incorporates (Figure 6.2-1 on page 25) a flowchart as a tool for determination of material attractiveness level. This paper will focus on several categorization schemes from this flowchart resulting in lower levels of attractiveness that may be present at domestic commercial reprocessing facilities, shown in Table 2.

Table 2. Salient Material Attractiveness Levels Relevant for Potential Future Commercial Domestic Reprocessing Facilities

Material	Physical Form	Concentration	Attractiveness Level
^{235}U of any enrichment	Any	< 20 weight % SNM	E
Pu/^{233}U	Solid	≤ 0.1 weight % SNM	E
		> 0.1 weight % but < 10 weight % SNM	D
	Solution	< 1.0 g/L	E
		≥ 1 g/L but < 25 g/L	D
		> 25 g/L	C

[17] Retrieved directly from DOE-STD-1194-2019, p. 26.

- Weight % SNM is calculated by dividing the weight of the SNM in the item by net weight of the item. The net weight of the item is "the weight of the material containing the SNM without simple mechanical removal of cladding or packaging that is determined by a qualified measurement method."[18]
- However, Section 6.2.1.1.1 of DOE-STD-1194-2019 includes several methods of how a site may choose to lower the attractiveness level of an item through various methods of analysis.
    - 6.2.1.1.1.1 describes how radiation may be considered self-protecting and the material reduced to an Attractiveness Level of E with an analysis including adversary task list, timeline, and whether the adversary will complete all tasks before incapacitation.
    - 6.2.1.1.1.2 describes how weight may be considered a mitigating factor if an item's removal would require the use of special tools or equipment, and the tools or equipment are controlled, locked, and alarmed.
    - 6.2.1.1.3 describes weight percent as a consideration for items containing less than one weight % Pu or less than one weight % ^{235}U.

It may be plausible for SNM of Attractiveness Levels D and E per the DOE Standard 1194-2019 to be subject to less-stringent NRC physical protection requirements when compared to existing NRC Strategic SNM Category I requirements. According to the Graded Safeguards Tables in Appendix B of the DOE Standard 1194-2019, attractiveness Level D materials do not have the potential to reach a Category I quantity, only reaching up to and including Category II quantities. Attractiveness Level E materials are not capable of reaching any DOE Category (I through III) quantity other than "Reportable Quantities." For Solutions ≥ 25 g/L, Attractiveness Level C materials can reach a Category I quantity for solutions with ≥ 6 kg of Pu / ^{233}U or ≥ 20 kg of ^{235}U. This approach is generally consistent with the NRC's proposed approach in the 2015 regulatory basis for the Rulemaking for Enhanced Security of Special Nuclear Material. This Rulemaking is discussed further below, including considerations of the dilution factor. It should be noted that this proposed Rulemaking was never finalized. However, the Rulemaking does provide technical insights useful for this paper's analysis.

3. NRC Staff's Proposed Multidimensional Categorization Scheme

In the Enhanced Security of SNM Rulemaking, the NRC staff proposed a multi-dimensional categorization based on the existing material categorization table but supplemented it with a dilution factor accounting for material attractiveness.[19] The dilution factor considers the amount of nuclear material relative to the total weight of the SNM-containing material that is not mechanically separable from the SNM. Mechanically separable means "separation of SNM-containing material from non-SNM material (container, cladding, mixture, etc.) can be accomplished by a simple mechanical operation that does not require specialized tools or processes and that does not considerably increase the adversary's mission timeline (time-on-target)."[20] The staff recommended several new measures that would be associated with the proposed categorization scheme:

- The staff would evaluate whether alternate or additional measures may be necessary on a case-by-case licensing application basis.

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[18] DOE-STD-1194-2019, p. 24.

[19] See page 40 of NRC's 2015 regulatory basis for the Enhanced Security of Special Nuclear Material Rulemaking for definition of "dilution factor" as: *the weight of uranium 235, uranium-233 and plutonium divided by the total weight of the SNM material and non-SNM materials which are not mechanically separable from the SNM) for solids and as grams of HEU, uranium-233 and plutonium per liter of solution for liquids*.

[20] For further examples of "mechanically separable," see further descriptions on page 32 of the NRC's 2015 regulatory basis for the Enhanced Security of Special Nuclear Material Rulemaking.

- Licensees with Category I SNM would be required to conduct an insider risk analysis and implement physical protection measures to resolve vulnerabilities identified within the analysis.
- Training and qualification plans, performance testing, contingency equipment, and weapons requirements should be revised for Category I SNM facilities.
- New functional areas were recommended for the proposed SNM security measures such as security program review, compensatory measures, suspension of security measures, and alternative measures.
- The staff propose moderately dilute material to be material possessing "a dilution factor equal to or greater than one percent, but less than 20 percent for uranium-235 and equal to or greater than one percent but less than 10 percent for uranium-233 and plutonium for solids and ≥ 1 gram per liter and < 25 gram per liter for HEU, uranium-233 and plutonium solutions."[21] The staff propose a requirement scheme that would apply a slightly less rigorous set of protection requirements against theft applicable to moderately dilute Category I SNM compared to the protection requirements against theft applicable to non-dilute Category I SNM.
- Material with an external dose rate of 50 Gray (5,000 Rad) per hour at one meter would be considered "self-protecting" and would not require physical protection for theft or diversion. However, sabotage requirements applicable to the type of facility per 10 CFR 73 (and potentially 10 CFR Part 37 per the 2015 regulatory basis document for the Rulemaking for Enhanced Security of SNM in future scenarios) may still apply.
    a. An example of a facility to reprocess spent irradiated fuel for the production of molybdenum-99 defines a "very high radiation area" as an area with radiation levels exceeding 5 Sieverts (500 rem) per hour at one meter and that the hot cell would likely exceed this rate.[22] According to the NRC, for practical purposes 1 rad absorbed dose = 1 rem dose equivalent.[23]

4. Proposed Approach for Reprocessing Facility Physical Security

In Table 4-3 of the NRC's 2015 regulatory basis document, the staff proposed physical protection requirements of "moderately dilute" Category I material that are equivalent to those for Category II material. Further specifications are outlined in Attachment 4 of the document for moderately dilute Category I SNM. Several of the most salient proposed requirements instruct that the licensee should:

- Implement a protective strategy with the performance objective to **immediately detect attempts of theft and provide sufficient delay for a local law-enforcement agency (LLEA) to promptly recover SNM**.
- Develop and implement security plans, including a physical security plan, a safeguards contingency plan, and a training and qualification plan.
- Provide defense-in-depth as well as implement the principles of redundancy and diversity.

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[21] NRC, 2015 regulatory basis for the Rulemaking for Enhanced Security of Special Nuclear Material, page 40, https://www.nrc.gov/docs/ML1432/ML14321A007.pdf.

[22] Safety Evaluation Report Related to the Northwest Medical Isotopes, LLC Construction Permit Application for a Production Facility, Docket No. 50-609, Northwest Medical Isotopes, LLC, U. S. Nuclear Regulatory Commission Office of Nuclear Regulation, November 2017, 11-29, https://www.nrc.gov/docs/ML1731/ML17310A368.pdf.

[23] "Measuring Radiation", U.S. Nuclear Regulatory Commission, page Last Reviewed/Updated Friday, March 20, 2020, https://www.nrc.gov/about-nrc/radiation/health-effects/measuring-radiation.html.

- Develop and implement an access authorization program that meets 10 CFR Part 11 requirements.
- Develop and implement a system to identify and correct deficiencies in the physical security program.
- Include the following barriers in the design of its physical protection system:
    - A vehicle barrier system to preclude large vehicle bombs from impacting ability of security system to provide adequate protection.
    - An isolation zone next to the protected area perimeter barrier to facilitate intrusion detection and assessment.
    - A controlled access area.
    - A protected area within the controlled access area.
        - Penetrations of the protected area perimeter should be locked and alarmed or monitored to detect unauthorized entry.
        - Protected area exteriors should be periodically monitored.
    - Intermediate storage of moderately dilute Category I SNM should be in locked compartments or locked process equipment.
    - A vault-type room (VTR) for material storage. The room should be equipped with intrusion detection equipment.
    - A bullet-resistant hardened central alarm station.
- Implement access controls to control access of persons, vehicles, and material at each access control point.
    - The individual responsible for fulfilling the last access control function should be isolated to facilitate the initiation of a response.
- Implement search programs to ensure the effectiveness of the protective strategy.
    - Vehicles and persons entering protected areas should be searched to verify authorization access.
    - The search programs should detect, deter, and prevent introduction of firearms, explosives, incendiary devices and other items that could assist an adversary in the theft or diversion of SNM.
- Implement intrusion detection and assessment systems capable of ensuring the protective strategy.
    - The licensee should detect attempted intrusion by unauthorized individuals.
    - Detection and assessment systems should possess tamper-indicating transmission lines.
    - An uninterruptable power supply should ensure the operability of the intrusion detection and assessment system in the case of loss of power.
    - Alarms should annunciate and video playback should occur in one continuously staffed central alarm station (CAS) in the protected area boundary. The CAS should be located on-site and should be constructed so that a single act cannot undermine the performance of the alarm station. A secondary alarm station (SAS) must also be permanently staffed, but may be located off-site or on-site.

- Implement illumination in the protected area exterior and isolation zone sufficient to provide assessment, of at least 0.2 foot-candles.
- Maintain communication with on-site and off-site resources to ensure adequate implementation of the protective strategy.
- Implement and maintain an on-site armed security force capable of interrupting unauthorized activities until an LLEA can arrive and engage to recover the SNM.
    - The licensee should maintain armed members of the security organization on site at all times, who may engage in lethal force according to applicable laws covering rules of engagement and escalation-of-force policies.[24]
    - The licensee should maintain agreements with LLEAs and conduct annual training exercises to familiarize the agencies with the site as well as to review the protective strategy and response plans.
- Conduct a security exercise at least annually to test its protective strategy and security plans.
- Review each element of its physical security program at least once every two years.
- Develop, maintain, and implement a maintenance and testing program to ensure security systems are functioning according to their intended and documented requirements.
    - Intrusion alarms should be tested at least once every seven days.
    - On-site communication equipment should be tested for operability at least at the beginning of each security shift.
    - Primary and backup communication equipment operability testing between alarm stations and LLEAs should occur at least once per day.
    - Search equipment should be tested for operability once per day and performance tested at least once every week.
- Implement compensatory measures if necessary to provide equivalent protection in the case of degraded or inoperable equipment.
- Implement a system for suspension of security measures when doing so is necessary to protect the public or personnel health and safety.

4.1 Facilities with Multiple SNM Categories

For fuel cycle facilities with multiple disparate SNM categories on site, typically the SNM of the highest category or the total SNM at the facility would drive the requirements for the protective strategy. Consideration must be given to aggregation of all SNM on the overall facility's categorization. However, a justification may be made for a coordinated protective strategy that leverages a dedicated on-site response force for a specific physical security area (such as Category I SNM within a VTR) while leveraging off-site response for a separate storage area such as a VTR containing moderately dilute SNM. If sufficient delay could be provided for the moderately dilute SNM, off-site response may be capable of providing the performance objective function to promptly recover the SNM.

[24] From NRC: "the use of deadly force is necessary in self-defense or in the defense of others, or any other circumstances as authorized by applicable State or Federal law," 2015 regulatory basis document for the Rulemaking for Enhanced Security of Special Nuclear Material, Page D-9.

The licensee should demonstrate through scenario analysis, along with the use of tools such as tabletop exercises and modeling and simulation, how the coordination would occur and demonstrate the overall effectiveness of the system to prevent theft of SNM. The licensee should also ensure to coordinate periodic training exercises at least annually to test protocols for the communication and exchange of information between the on-site and off-site response resources. The response organizations should be coordinated under a single overall governing security plan, owned by the licensee, with clearly delineated roles, responsibilities, and chain of command. An integrated physical protection system leveraging the same protected area for both SNM areas would be coordinated through the CAS and SAS to provide command and control for the protection of both targets. Applicants that wish to rely upon an off-site armed response may find helpful guidance in Appendix A of proposed Regulatory Guide 5.90 (currently DG-5072). While this guidance is for how off-site response organizations can provide the interdiction and neutralization functions for nuclear power plants, certain aspects of the document may provide insights into how licensees conduct training exercises, drills, and knowledge transfers and may establish agreements to provide reasonable assurance of adequate protection. The guidance also provides insight and discussion on information licensees may use to justify the use of coordinated on-site and off-site response forces, such as

- the establishment of a memorandum of understanding (MOU),
- turnover,
- command and control,
- notifications of events,
- conduct of drills, tabletop and force-on-force (FoF) exercises,
- scenario development, and
- information security.

4.2 Sabotage

As previously mentioned, the NRC has not established a regulatory framework for commercial reprocessing facilities, so if and how sabotage requirements would apply in this situation is uncertain. It could be envisioned that some form of the radiological sabotage DBT defined in 73.1(a) currently applicable to commercial nuclear power plants and Category I SNM facilities may be repurposed to apply to commercial reprocessing facilities if the potential radiological consequences of sabotage are commensurate. For facilities with a combination of commercial nuclear power and reprocessing facilities containing moderately dilute Category I SNM, the licensee may confer with NRC regarding how to implement the protection requirements for the DBT of radiological sabotage along with material theft protection requirements. The licensee should also consult with NRC regarding the specific areas of the facility where these requirements are implemented. If the protection requirements of the DBT of radiological sabotage are only applied within the protected area of the facility, once the material leaves the protected area but is still within the limited-access area of the facility, additional protection requirements beyond those typically present within the limited-access areas of nuclear power plants but outside of the protected area may be needed to provide a commensurate level of protection. Table 3 summarizes this discussion for moderately dilute Category I SNM.

Table 3 – Summary of Potential Protection Paradigms When Combining Theft and Radiological Sabotage for Moderately Dilute Category I SNM

Moderately Dilute Category I SNM Meets Self-Protecting Standard?	Material is Within/Outside of Protected Area?	Potential Applicable Requirements
Yes	Within protected area	DBT of radiological sabotage
Yes	Outside protected area but within limited-access area	This may be unallowable since the material subject to radiological sabotage would likely be required to be located within a protected area.
No	Within protected area	Moderately dilute theft requirements, & discuss application of DBT of radiological sabotage with NRC
No	Outside protected area but within limited-access area	Moderately dilute theft requirements, & consider sabotage for Pu

4.3 Summary of Comparisons to Category I SNM Security

Table 4 summarizes the most salient differences between the NRC's proposed moderately dilute Category I physical protection requirements and the proposed Category I requirements. A more thorough comparison summary can be found in Table 4-3 of the NRC's 2015 Enhanced Security of SNM regulatory basis document.

Table 4 – Salient Differences Between Proposed Category I and Moderately Dilute Category I SNM Physical Protection Requirements, Retrieved from the NRC's 2015 Regulatory Basis Document.

Element	Category I	Moderately Dilute Category I
Performance Objective	Protection against the DBT of radiological sabotage and theft. Prevent the removal of SNM and other unauthorized activities involving SNM.	Immediately detect attempts to remove SNM and the provision of sufficient delay for LLE to promptly recover SNM.

Element	Category I	Moderately Dilute Category I
Insider	Insider risk analysis to inform scenarios of theft. Insider mitigation program in PSP containing elements from Part 11 Access Authorization program, Part 26 Fitness-for-Duty, and Part 74. Behavioral Observation Program implementation. This includes reporting of behavioral concerns, periodic training and reporting of legal actions. Two-person rule for Material Access Area.	Access authorization program consistent with 10 CFR Part 11.
Armed Members of the Security Organization	Armed tactical responders must be available and inside the protected area at all times. The minimum number of tactical responders should not be less than ten.[25] Armed security officers should also be on site and available at all times to strengthen the response. There is no minimum number.	No mention of armed tactical responders. Armed guards must be available and on site at all times, but no minimum number is specified. Licensees are exempt from tactical response training and qualification portion of Part 73 Appendix B.
Vital Areas	Yes. At a minimum, the central and secondary alarm stations should be vital areas. The secondary power supply systems for alarm annunciation and non-portable communications equipment should be within a vital area.	Not mentioned, but VTR is.
Individual Responsible for Last Access Control Function	Isolated in a bullet-resisting structure.	Isolated, but does not specify bullet-resisting.
Alarm Stations	Two continuously staffed on-site alarm stations (central and secondary alarm stations). Both should be bullet-resisting.	Central alarm station should be on site, but secondary alarm station can be located off site. Both must be continuously staffed. Only the CAS is specified to be bullet-resisting.
Material Access Area	Yes and two-person rule.	Not mentioned.

[25] It is noted that the 2015 NRC regulatory basis document has “eight” listed as this minimum number on page C-15, while the summary table has ten.

5. Conclusions and Recommendations

Domestic reprocessing facilities may be pursuing licensing in the near future from the U.S. NRC. Several characteristics of the SNM throughout its processing may provide technical justification for it to be subject to less-rigorous physical security requirements when compared to Strategic SNM (Category I SNM) under current NRC requirements. For example, it may be plausible that a facility targeting a product of below 20 weight % of ^{235}U of any enrichment and less than 10 weight % Pu may have a case for application of physical security requirements similar to those proposed for moderately dilute Category I SNM in the NRC's 2015 regulatory basis document for the Enhanced Security of SNM Rulemaking, summarized in Table 4. Insights from NRC security-related rulemaking activities provide a substantial technical basis to approach potential establishment of physical security requirements for reprocessing facilities. If a licensee can provide justification that the material satisfies a sufficient self-protecting radiation dose threshold, the material may not be subject to theft or diversion requirements and only potential sabotage requirements would apply. Furthermore, if the material can be justified to be moderately dilute, a set of risk-informed requirements could provide adequate protection of public health and safety. A revised performance objective for prevention of theft of moderately dilute Category I SNM may be for the licensee to "immediately detect attempts of theft and provide sufficient delay for a local law-enforcement agency (LLEA) to promptly recover SNM." On-site armed members of the security of the organization and barriers should be leveraged to provide sufficient delay to allow LLEAs to promptly recover SNM. However, the number of armed security personnel is not prescribed, and tactical responders are not required.

However, a significant caveat to the proposed categorization scheme is the unknown integration of radiological sabotage with theft protection requirements. Future licensees should consult with the NRC regarding treatment of this regulatory topic. Additionally, the self-protecting radiation dose threshold (existing or a proposed future threshold) would need to be considered. An integrated approach may apply graded potential protection requirements for protection against the DBT of radiological sabotage currently applicable to commercial nuclear power plants and Category I SNM facilities defined within 10 CFR 73.1(a). An applicant for a license of a commercial reprocessing facility may find helpful a review of proposed regulatory rule language and guidance for multiple ongoing NRC rulemakings for advanced small modular and non-light-water nuclear reactors.[26] Such proposed rules may provide insight into how the NRC would allow applicants to demonstrate a graded approach to implementation of physical security requirements.

[26] For further reading on proposed NRC rulemakings impacting physical security of advanced reactor technologies, including relevant proposed rule language and related guidance documents, please see the Alternative Physical Security Requirements for Advanced Reactors Proposed Rule, NRC Docket NRC-2017-0227, https://www.regulations.gov/docket/NRC-2017-0227, and Part 53 – Risk Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors, Docket ID NRC-2019-0062, https://www.regulations.gov/docket/NRC-2019-0062.