UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 7, 2022

Joy L. Rempe, Chairman
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: RESPONSE TO THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, "DRAFT SECY WHITE PAPER ON LICENSING AND REGULATING FUSION ENERGY SYSTEMS"

Dear Chairman Rempe:

On behalf of the U.S. Nuclear Regulatory Commission (NRC or the Commission) staff, I would like to thank you for the letter from the Advisory Committee on Reactor Safeguards (ACRS or the Committee) dated October 21, 2022 (Agencywide Documents Access and Management System Accession No. ML22290A177). This letter addressed the NRC staff's efforts to develop options and recommendations for Commission consideration of the licensing and regulation of fusion energy systems. I appreciate the time and effort that the ACRS devoted to this subject during subcommittee meetings and the ACRS Full Committee meeting on October 5, 2022.

The NRC staff's interactions with the ACRS were supported by the issuance of a September 2022 white paper[1] that summarized technical and administrative issues relevant to providing the Commission with options on regulating fusion energy systems. The forthcoming Commission options paper will include additional background information, technical detail, and regulatory considerations to address specific areas identified in your letter. The NRC staff provides the responses below to the four conclusions and recommendations in the ACRS letter.

1. A license issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 30 is appropriate for fusion facilities, provided tritium inventories are low (e.g., < 10 g active inventory) and activation is minimal (e.g., < 0.01 MW-yr/m2 or 0.1 dpa). This will result in regulatory certainty for near-term applications.

Staff Response:

The NRC staff agrees that ongoing research and development activities and near-term fusion energy system concepts that can be classified as particle accelerators and produce radioactive material consistent with the definition of byproduct material in the Atomic Energy Act can be appropriately licensed using the NRC's byproduct material regulatory framework contained in

[1] "NRC Staff Prepared White Paper—'Licensing and Regulating Fusion Energy Systems'—September 2022 Draft—Released to Support ACRS Interaction," September 2022 (ML22252A192).

10 CFR Part 30, “Rules of General Applicability to Domestic Licensing of Byproduct Material.”

The Nuclear Energy Innovation and Modernization Act (Public Law 115-439) directed the NRC to develop a technology-inclusive regulatory framework for commercial fusion reactors by the end of 2027. As such, the NRC staff is considering both anticipated near-term and potential future fusion designs in developing regulatory framework options for fusion energy systems. Based on interactions with stakeholders, the NRC staff recognizes that there is a spectrum of proposed technologies that present different hazard profiles based on the type of fusion reaction and radioactive material produced or stored on site. As part of building a predictable framework that provides regulatory certainty to developers, the NRC staff is considering the appropriateness of material and device requirements and regulations in areas such as design, licensing, operation, and decommissioning of fusion energy systems.

As it finalizes its Commission paper, the NRC staff will consider the Committee’s proposed thresholds for use of the NRC’s byproduct material framework. The NRC staff is also considering information provided by developers that reflects current fusion energy system designs. For example, tritium inventories, particularly the active inventory in the fusion device, are expected to be low (less than 100 grams) compared to the kilogram-size inventories in past conceptual designs used in safety studies. Also, the NRC staff intends to account for, but not presume, potential technological advances, such as the development of structural materials with lower neutron cross-sections to minimize activation products. The Commission options paper will reflect the NRC staff’s consideration of available material inventory and technology information to inform its recommendation of the appropriate regulatory framework for fusion energy systems.

2. The hybrid approach (Option 3—byproduct and utilization combined framework) should be pursued for higher consequence fusion energy facilities. Our rationale is summarized below.

    a. This approach provides needed regulatory flexibility given the diverse fusion design options, their broad range of hazards, and the large uncertainties associated with their performance at engineering- or power plant-scale.

    b. This approach implicitly recognizes engineering- or power plant-scale fusion energy systems share many characteristics (e.g., decay heat, mobilizable radionuclides) that may result in hazards more like fission reactors than like accelerators and are also similar to some utilization facilities licensed by NRC.

    c. This approach would allow time for development of regulations for future higher consequence facilities as experience is gained with early applications and operation of lower consequence fusion facilities.

    d. Scaling of Option 2 (byproduct 10 CFR Part 30 framework) with additional safety requirements as the technology evolves could result in a patchwork of regulations. The resulting 10 CFR Part 30 language may look more like what exists today for a utilization facility under 10 CFR Part 50.

Staff Response:

The NRC staff agrees with the Committee that the NRC's regulatory approach to fusion energy systems needs to be flexible and scalable to address the diverse array of concepts, the broad range of potential radiological hazards, and the uncertainties associated with the operation of such systems. As part of its continued work to develop options for the regulation of fusion energy systems, the NRC staff is considering the suitability of recommending to the Commission a hybrid approach (Option 3), which would introduce decision criteria to appropriately license and regulate fusion energy systems under either a byproduct material or a utilization facility regulatory framework based on an assessment of potential hazards.

As noted in the September 2022 white paper, the NRC and Agreement States currently regulate a variety of uses of radioactive material under the NRC's byproduct material framework and the National Materials Program. The current byproduct material framework covers a broad range of radiological hazards through requirements in areas such as radiation protection and emergency planning. The NRC staff has not identified specific technical limitations associated with the byproduct material framework that would preclude establishing requirements for containing tritium and other radionuclides and, if needed, in areas such as security and emergency preparedness.

As discussed in your letter, uncertainties associated with the development of commercial fusion energy systems, the associated radiological risks, and societal expectations could warrant applying a utilization facility framework to some future fusion energy systems. As described under Option 3 in the NRC staff's September 2022 white paper, the NRC staff is considering the possible regulation of fusion energy systems exceeding certain thresholds as utilization facilities. For example, the NRC staff could develop decision criteria through the rulemaking process to establish a threshold for categorizing fusion energy systems as utilization facilities. Fusion energy systems that do not exceed the decision criteria would be licensed under a byproduct material framework. One approach to defining the decision criteria could include consideration of tritium inventories and material activation. The staff would evaluate this and other potential approaches to setting the decision criteria as part of the rulemaking process.

If the Commission directs the NRC staff to prepare a regulatory framework for fusion energy systems using a hybrid approach, the NRC staff would proceed with establishing a byproduct material framework for near-term fusion energy systems and develop decision criteria for when a fusion energy system should be considered a utilization facility, as part of a two-phase approach. The NRC staff would continue to engage developers to prepare a future utilization facility framework based on the anticipated design and deployment of new fusion energy systems with greater risk profiles than currently understood with the contemplated near-term facilities.

3. Option 3 would enable an enduring holistic framework to be established for fusion power plants in the future.

Staff Response:

The NRC staff response to ACRS Recommendation 2 outlines the possible implementation of a two-phase hybrid approach to licensing and regulating fusion energy systems (Option 3). If directed by the Commission to pursue this option, the NRC staff agrees that such an approach would support the development of an enduring, holistic regulatory framework. The two-phase hybrid approach would (1) provide the predictability needed for near-term developers under a

byproduct material framework and (2) allow time for development of a utilization facility framework that benefits from stakeholder engagement; new information gained through research, licensing, and operating experience; updated designs, concepts, and technologies; and consideration of new or heightened hazards.

4. The white paper discussion on the hazards of fusion energy systems at engineering- or power plant-scale contains some factual inaccuracies and could benefit from additional context. This should be corrected.

Staff Response:

As part of the continued development of a Commission options paper recommending an approach to the regulation of fusion energy systems, the NRC staff is evaluating information originally included in the September 2022 white paper. The Commission options paper will include additional background information, technical detail, and regulatory considerations to address specific areas identified in your letter, including the expected magnitude of radiological hazards and the potential impact of such hazards on public health and safety. This additional information will more fully reflect NRC staff technical, licensing, and policy knowledge, as well as interactions with the U.S. Department of Energy, national laboratories, international organizations, and stakeholders related to research, development, licensing, and oversight activities for fusion energy systems.

Your letter notes several areas for the NRC staff to address, including tritium inventories, mobilizable radioactive material, decay heat, radiation damage, activated components, and waste generation. The NRC staff is considering current designs and technical information relevant to near-term fusion energy systems as it develops regulatory framework options. Near-term fusion energy systems are expected to be of a smaller scale than historically envisioned facilities. The tritium inventory at a commercial fusion power plant is expected to be less than 100 grams, with 0.1 gram or less in the vacuum chamber. The magnitude of energy sources and radioactive material inventories will influence the onsite and offsite dose during normal operations and credible accidents and will be considered by the NRC staff in the development of appropriate licensing requirements to protect health and safety of workers and the public.

Based on the information provided to date by developers, the NRC staff expects doses to the public resulting from the accidental release of radioactive material for near-term fusion energy systems to be less than the current threshold for requiring an emergency plan for byproduct material in 10 CFR 30.32(i) of 1 rem effective dose equivalent or 5 rem to the thyroid. Additionally, fusion energy systems may use low-activation materials (e.g., ferritic/martensitic steels, vanadium alloys, and silicon carbide/silicon carbide composites) that do not produce long-lived, highly radioactive waste that requires cooling before being moved to a repository for disposition. It is anticipated that most of the waste output from fusion energy systems will consist of low-level radioactive waste. However, some proposed designs may produce greater-than-Class C[2] waste and tritiated waste that will need to be assessed as commercial-scale fusion energy systems approach licensing.

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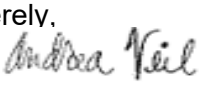
[2] The list of radioisotopes and specific activities that define Class C waste category limits in tables 1 and 2 of 10 CFR 61.55, “Waste classification,” will need to be expanded to include the radioisotopes of importance for fusion energy systems. Section 7.4 of DOE-STD-6003-96, “DOE Standard, Safety of Magnetic Fusion Facilities: Guidance,” issued May 1996, contains more details.

After receiving Commission direction, the NRC staff will develop any necessary requirements in 10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” to implement the National Environmental Policy Act (42 U.S.C. 4321 et seq.) for fusion energy systems, taking into consideration the types of licensing actions expected, the novelty of the technology, possible hazards, and the potential for licensed activities to affect the quality of the human environment.

The NRC staff appreciates the continued engagement from the ACRS on developing a regulatory framework for fusion energy systems and considers the Committee’s recommendations to be valuable input to this important topic. The NRC staff will engage the ACRS following Commission direction to prepare a regulatory framework for fusion energy systems to determine the need for future interactions between the NRC staff and the ACRS on fusion-related activities.

Sincerely,



Signed by Veil, Andrea
on 11/07/22

Andrea D. Veil, Director
Office of Nuclear Reactor Regulation

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