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Requirements for a Standard Commercial Advanced Burner Reactor

Nuclear Engineering Division

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Introduction

1. The Advanced Burner Reactor (ABR) is a key component of the Global Nuclear Energy Partnership (GNEP) initiative for recovering transuranic elements (TRU) from spent nuclear fuel and recycling these elements as reactor fuel. By recycling the TRU as fuel, the long-term radiation hazard resulting from the spent fuel is significantly reduced, the demand on a geologic repository for spent fuel is also significantly reduced and useful energy is recovered by fissioning the TRU in the ABR.

2. This document is intended to convey the expectations of the Department of Energy (DOE) for the principal attributes of an ABR design. It is to be used along with the regulations and guidance of the US Nuclear Regulatory Commission (NRC), the US Environmental Protection Agency (EPA) and other appropriate requirements documents and standards to formulate an overall set of requirements for an ABR design. The design team is expected to use creativity and ingenuity in developing a design that satisfies these expectations. The design team may propose an exception or alternative to one or more of the provisions of this document in formulating its overall design requirements, but shall justify the proposed change to DOE's satisfaction.

3. The requirements included in this document are intended to apply to a design for a standard commercial nuclear power plant based on an Advanced Burner Reactor. Since these nuclear power plants would be operated in the commercial sector, they will be licensed by the US Nuclear Regulatory Commission (NRC), and this requirements document reflects that expectation.

4. Current plans are that a **prototype ABR** would be designed, built and operated as part of a development and demonstration program, having the goals of demonstrating the transmutation of TRU in a fast reactor, demonstrating operation of the ABR as part of the system for recovering and recycling TRU as fuel, qualifying the transmutation fuel, testing new materials and components, and supporting design certification of the standard commercial ABR power plant by the NRC under 10CFR52. The **prototype ABR** must be sufficiently close in design to the commercial ABR to effectively perform these functions. Therefore, the requirements set out in this document should apply to the **prototype ABR** as well, with a few additional requirements to reflect the purposes of the prototype. These additional requirements are clearly indicated in the document.

5. As a prototype of a fast reactor intended to be used in a commercial nuclear power plant, it is assumed herein that the **prototype ABR** will be licensed by the US NRC

[1] The document also provides additional requirements for a prototype ABR. See the Introduction, paragraph 4.

as specified by the Energy Reorganization Act of 1974. However, if a decision is made that DOE will license the **prototype ABR**, rather than NRC, it will be necessary to make appropriate changes to references to NRC regulations to refer instead to the corresponding DOE regulations, primarily those found in 10CFR830 and 835, and related Orders and other documents.

6. Both the commercial ABR and a **prototype ABR** will be subject to International Atomic Energy Agency (IAEA) safeguards. If operated in the US, it is an open question as to whether the IAEA will actually choose to safeguard the facility. Should an ABR be constructed in another country, it would be subject to IAEA safeguards. Accordingly, design of the ABR shall incorporate the ability to meet international safeguards criteria.

Requirements

1. High-level Requirements

1.1. Functional Objectives

1.1.1. Electricity production in a commercial environment: The ABR shall be designed for safe and efficient production of electricity. Also, the ABR shall be designed to operate in a commercial environment (i.e., on an electrical grid). Accordingly, an efficient energy transport and conversion system is required, and the ABR shall be designed with sufficient operational control, flexibility, and availability to ensure compatibility with the demands of such an environment.

1.1.1.1. Capacity Factor: For the ABR power production mission, the commercial ABR design shall be such that a capacity factor greater than 90% can be achieved.

1.1.2. Power plant size: The reference power rating for the **prototype ABR** is expected to be in the range of 250 to 2000 MWt; in any case, it shall be large enough to fulfill the objectives of the **prototype ABR** set out in paragraph 4, above. It is expected that the commercial ABR will be larger, in the 1500 MWe class. For the commercial ABR, either a single unit or a modular, multiple power unit approach may be proposed by the design team.

1.1.3. Burning of plutonium and minor actinides: The principal purpose of the Advanced Burner Reactor (ABR) is to transmute transuranic elements (TRU) by fissioning. Therefore, the ABR shall be designed to operate safely and efficiently using ‘transmutation fuel’ containing plutonium and minor actinides. In the **prototype ABR**, it may be necessary to allow for flexibility in operation with various fuel types, considering both fuel composition (TRU, U/Pu, HEU, etc.) and fuel form (oxide, metal, etc.), so the **prototype ABR** shall have the capability to operate safely and efficiently for a range and/or mixture of fuel types.

1.1.3.1. **Transuranic consumption targets:** The ABR shall be designed for a net consumption ("burning") of transuranics (TRU) at a rate of 0.25 to 0.50 grams TRU/MWt-day when optimized for cost and other performance characteristics. The design team shall propose the core design options, such as absence of blankets, needed to achieve this goal. The **prototype ABR** shall include the capability for testing advanced fuel forms and alternate core configurations designed for a wider range of TRU management options (i.e., significant TRU enrichment variations, fuels containing no fertile material, etc.).

1.1.4. **Cost objective:** To be successful, the ABR must function as part of a commercially viable system, which includes LWRs, ABRs, reprocessing and fuel-fabrication facilities and waste disposition. A design objective shall be that the capital and operating cost of the future commercial ABR will be such that, when considered in the context of the overall benefits of the ABR transmutation system, the cost of the electricity produced is competitive in the marketplace. The design of the **prototype ABR** shall minimize cost consistent with achieving the principal goals of the ABR development and demonstration program

1.1.5. **Non-proliferation and nuclear security:** The ABR design shall include proliferation resistance as a design objective. The design of the standard commercial ABR shall facilitate domestic and international safeguards activities and include provisions to protect against theft or diversion of nuclear materials and to protect against security-related threats. The design of the **prototype ABR** shall enable testing of advanced equipment and systems that can enhance proliferation resistance and nuclear security.

1.2. Supporting Technical Requirements

1.2.1. **Fast neutron spectrum:** To ensure that transmutation of plutonium and minor actinides can be accomplished efficiently without excessive buildup of higher actinides, the ABR shall provide a fast neutron spectrum.

1.2.2. **Sodium coolant:** The ABR design shall take advantage of well-established fast reactor coolant and component technology and operating experience to the maximum extent possible to minimize technical risk and expedite design and construction. To this end, the reactor shall use liquid sodium coolant.

1.2.3. **Design of a prototype reactor:** The **prototype ABR** shall be designed to satisfy the functions of a prototype reactor, including but not limited to demonstration of reactor based transmutation of TRU isotopes, qualification of the transmutation fuel, testing of advanced structural materials and developing an understanding of the cost drivers of this portion of the overall system. Accommodation of testing of advanced fuels, components and systems shall be a design goal for the **prototype ABR**.

1.2.4. **Irradiation environment in the prototype ABR:** The **prototype ABR** shall be sized to provide an irradiation environment that is prototypic of the conditions to be expected in commercial ABRs. A single module of a modular plant design or a reduced size version of a large, single unit design would be acceptable if a prototypic environment is achieved.

2. <u>General Requirements</u>

2.1. **Compliance with regulations, codes and standards:** The ABR design shall comply with NRC regulations and other applicable codes and standards, including but not limited to those published by the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE), the American Nuclear Society (ANS), and the Institute of Electrical and Electronic Engineers (IEEE). In case of conflict between NRC's requirements and those of other codes and standards, the NRC requirements shall take precedence.

2.1.1. Proven design methods and design features shall be used to the extent possible. When new or innovative features are introduced, they shall be proven by analysis, test or both, followed by demonstration in the prototype reactor.

2.2. **Detailed design requirements and documentation:** The design team shall divide the reactor and plant design into appropriate systems. For each system, a System Design Description (SDD) shall be prepared to document the detailed functions and requirements for that system, along with the details of the design. The design team shall show that the detailed functions and requirements in the SDD are traceable to and support the requirements in this document and/or any other higher level requirements agreed with DOE, and that the design satisfies the detailed functions and requirements.

2.3. Quality assurance: All safety-significant[2] structures, systems and components (SSCs) of the ABR shall be designed, built and operated in accordance with a quality assurance program that meets the requirements of 10CFR50, Appendix B, or an alternative standard (such as ANSI N45.2.11, "Quality Assurance Requirements for the Design of Nuclear Power Plants") as agreed with the NRC. Non-safety significant SSCs may be designed, built and operated under an appropriate alternative quality assurance program that will ensure that high industrial and commercial quality standards are observed.

2.4. Licensing by the NRC: The ABR shall be designed and operated to ensure that the public, the site workers and the environment are protected against undue exposure to radiation. The design, development and demonstration program shall be conducted with the long term goal of obtaining design certification of a standard design under 10CFR52. Appropriate interactions with the NRC shall take place prior to submittal of a formal license application. In line with the NRC's philosophy of using risk-informed, performance-based approaches, the ABR's design shall be based on that philosophy from the outset. Interactions with the NRC shall be a major vehicle for assuring that the philosophy is being appropriately followed.

2.5. Meeting NRC's safety goals: The ABR safety design requirements shall meet the Commission's Quantitative Health Objectives as expressed in the Safety Goal Policy Statement[3], as well as the Commission's expectations for safety of new and advanced design reactors[4].

2.5.1. To facilitate future licensing outside the USA, accepted international safety standards (such as the IAEA Safety Standards) should be considered in formulating the safety design requirements for the ABR.

3. Safety and Security Requirements

3.1. Safety assessment and PRA: As required by the NRC, a comprehensive safety assessment shall be performed and documented in a Safety Analysis Report. This safety assessment shall include a probabilistic risk assessment (PRA), which shall be performed as an integral contributor to informing the design process. The PRA shall be used to ensure that an acceptable risk

[2]The term 'safety significant' SSCs includes those designated as 'safety related,' 'safety significant' and 'important to safety' in current NRC terminology. The functionality of such SSCs plays a role in meeting the acceptance criteria for licensing basis events (see section 3.3), so they require special treatment, the nature of which depends on the function and importance of the SSC.

[3] Safety Goal Policy Statement, "Safety Goals for the Operation of Nuclear Power Plants," 51 FR 30028, August 21, 1986

[4] "Commission Policy Statement on the Regulation of Advanced Nuclear Power Plants," 51 FR 24643, July 8, 1986; 59 FR 45461, July 12, 1994

profile is achieved, and to help to select the licensing basis (or design basis) events and to ensure that defense-in-depth is achieved.

3.1.1. The PRA shall be of sufficient quality (i.e., scope, level of detail and technical adequacy) to support risk-informed licensing decisions. Appropriate PRA quality standards shall meet NRC's expectations, specifically those expressed in the Commission's Phased Approach to PRA Quality.

3.1.2. It shall be assumed that the PRA will be maintained as a 'living PRA' to support operations, inspection and maintenance activities throughout the life of the plant. Appropriate quality standards will be established and observed.

3.2. **Frequency-consequence curve:** An acceptable risk profile shall be derived based on the existing regulations in 10CFR20, 50 and 100, and EPA Protective Action Guidelines and expressed in a frequency-consequence curve (F-C curve) relating frequencies of undesired event sequences to the corresponding acceptable consequences.[5] In its draft "Framework for Development of a Risk-Informed, Performance-Based Alternative to 10 CFR Part 50," the NRC has developed the relationship shown in the Appendix to this requirements document. Use of this F-C curve or an alternative shall be agreed with the NRC.

3.3. **Protection against off-normal and accident events:** The ABR shall be designed to provide protection against off-normal and accident events. Licensing basis events (or off-normal, design-basis and beyond-design basis accidents) shall be defined. The performance of the ABR in providing protection against these events shall satisfy the F-C curve and the following additional deterministic criteria (demonstrated by calculations at the 95% probability value):

3.3.1. For 'frequent' events expected to occur at least once in the lifetime of a plant (frequency greater than 10^{-2}/reactor-year), there shall be no impact on safety analysis assumptions and no barrier failure. Redundant means of reactor shutdown and decay heat removal shall remain functional.

3.3.2. For 'infrequent' events expected to occur at least once in the lifetime of a population of plants (frequency less than 10^{-2}/reactor-year and greater than 10^{-5}/reactor-yr), a coolable geometry shall be maintained, at least one physical barrier shall remain, and at least

[5] In the absence of a specific site for the **prototype ABR**, site related calculations shall be based on the most limiting of the characteristics of the 11 sites identified for detailed siting studies for integrated spent fuel recycling facilities under the GNEP initiative.

one means of reactor shutdown and one means of decay heat removal shall remain functional.

3.3.3. For ‘rare’ events not expected to occur in the lifetime of a population of plants (frequency less than 10^{-5}/reactor-yr), no additional deterministic criteria apply.

3.3.4. In addition to the above requirements, the design team shall establish as goals a core damage frequency of 10^{-6}/reactor-yr and a large release[6] frequency not exceeding 10^{-6}/site-yr for multi-reactor sites.

3.4. Defense-in-depth: The ABR design shall provide for defense-in-depth against uncontrolled release of radioactive material. The design shall provide suitable features to prevent accidents, limit accident progression, maintain containment integrity and mitigate radiological consequences of a release. Defense-in-depth measures shall also be provided for physical protection and protection against security-related threats. Safety margins shall be provided to account for uncertainties in performance of humans and SSCs, and uncertainties in the analyses. The design team may develop additional deterministic criteria to evaluate the design features for defense-in-depth, in addition to meeting the criteria of Section 3.3.

3.4.1. Principles of redundancy, diversity and independence shall be observed to ensure that no single failure or removal from service of an active or passive component can result in loss of a safety or security function or loss of required redundancy in performance of a safety or security function. Performance of safety and security functions shall not depend on a single element of design, construction, maintenance or operation. At least two redundant, diverse and independent means for reactor shutdown and decay heat removal shall be provided, and there shall be at least two barriers to fission product release.

3.5. Risk-informed classification: Classification of structures, systems and components shall be risk-informed, and safety significant SSCs shall be identified and given special attention throughout their life cycle to ensure that they can perform their functions in accordance with the assumptions made in the PRA and SAR.

3.6. Passive safety features: In addition to the engineered systems described in Section 3.4 to provide defense-in-depth, the ABR design shall incorporate passive means of performing the fundamental safety functions of reactivity control, heat removal and containment of radioactive materials to the extent

[6] A large release is a release of volatile radionuclides into the environment that could result in a prompt fatality to a member of the general public.

possible consistent with design goals for operability, reliability and cost. Examples of passive means include inherent negative reactivity feedbacks, thermal expansion of fuel and structures, low excess reactivity and mechanical stops to limit the magnitude of potential positive reactivity insertion from control rod withdrawal, natural circulation heat removal systems, guard vessels to limit sodium leakage, and a low leakage containment building.

3.6.1. The ABR design shall include features that reduce to as low a level as practical the likelihood and consequences of a sodium fire, sodium-water or sodium-concrete interaction or chemical interaction of sodium with other materials with which it is not compatible. Sodium leak detection systems shall be provided. Use of inerted cells for sodium equipment, capability for rapid draining of the secondary sodium system and similar measures may be considered.

3.7. Protection against security-related events: As a minimum, the ABR shall have the same level of protection against security-related threats as established by 10CFR73 and the NRC's post-9/11 orders[7], and shall satisfy the NRC's expectations for security design of new reactors[8]. A security vulnerability assessment shall be performed during the design phase of the facility, as well as prior to licensing and operation. Such an assessment shall consider, as a minimum, the areas mandated by the NRC. Security shall be accomplished by design to the extent practical. Defense-in-depth shall be provided to compensate for uncertainties. Details of the application of probabilistic performance standards shall be agreed to with the NRC.

3.7.1. The ABR design shall provide for detection and surveillance sufficient to detect theft or diversion of material that could result in an Extraordinary Nuclear Occurrence, as defined in 10CFR140.

3.8. Safety and security preparedness: Specific design features to provide for safety and security preparedness shall be incorporated into the ABR design. Examples of such features may include provisions for protecting the control room(s), emergency operations center and vital areas of the plant in case of an accident or attack. At a minimum, the expectations of the NRC shall be met in the design.

3.9. Emergency preparedness: Appropriate design features for emergency preparedness shall be included. Examples may include an auxiliary control room, emergency operations center, emergency communications, accident management measures and emergency procedures.

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[7] All Operating Reactor Licensees, Order Modifying License EA-02-26, 67 FR 9792, March 4, 2002, and EA-03-086, 68 FR 24517, May 7, 2003

[8] SECY 05-0120, "Security Design Expectations for New Reactor Licensing Activities," September 9, 2005

3.10. Integrated design: Safety, security and emergency preparedness shall be considered as an integrated whole in the design of the ABR.

4. Design Requirements

4.1. Design life: The design life of the ABR shall be determined based on the expected lifetime of materials used in structures, systems and components (SSCs). Aging and degradation mechanisms shall be considered in the design. It is expected that the ABR will have a design life similar to that of advanced light water reactors.

4.2. Design for simplicity, low cost and high availability: The ABR design shall emphasize simplicity, ease of fabrication, installation, operation, inspection and maintenance to promote reliability of SSCs, minimize capital and operating cost and maximize availability of the plant.

4.3. Design for reliability: Structures, systems and components shall be designed for a high level of reliability to increase plant availability, decrease costs and reduce risk. Principles of redundancy, diversity, physical separation and independence shall be applied to eliminate the likelihood of common cause failures.

4.3.1. Auxiliary services and equipment that support a safety significant function shall be considered to be part of that function and classified accordingly. Failure of a non-safety significant SSC shall not affect safety by causing failure of a safety significant SSC.

4.4. Design for flexibility in siting: The ABR shall be suitable for deployment on the widest possible variety of sites within the United States. To this end, the design shall reduce vulnerability to external events, such as earthquakes, floods, wind storms, human-caused external events, etc.

4.4.1. In the absence of identification of a specific site, the **prototype ABR** shall be suitable for deployment on any of the sites that have been identified for detailed siting studies for integrated spent fuel recycling facilities under the GNEP initiative.

4.5. Seismic design: The ABR's safety-significant structures, systems and components shall be designed for earthquake resistance using the current NRC regulatory scheme, or (if it is adopted) the performance-based scheme that the NRC has recently proposed for design certification of new light-water reactors (LWRs). The objective of the approach taken for the ABR (like that taken in design of the LWRs that have received design certification) shall be that the ABR could be sited in most of the United States without modifying the seismic design basis. (It is recognized that in areas of very high seismicity, such as coastal California, a special design approach may be necessary.)

4.6. Design for external events: The ABR design shall include generic provisions to accommodate hazards other than earthquakes, high winds and external flooding that originate from outside the plant site, including but not limited to external explosion, toxic gas release, rare meteorological events, floods, etc. Specific provisions depending on the site characteristics shall be incorporated as necessary when a site is identified.

4.7. Protection against internal fires: The ABR design shall provide comprehensive systems for protection against internal fires, considering both normal fires and sodium fires. The impact of smoke and toxic fumes from fires shall be considered in the design of the control room and safety significant SSCs. Use of a risk-informed approach to design for fire protection shall be agreed with the NRC.

4.8. Normal heat transport: The normal system for heat transport from the reactor to the power conversion system shall be such that radioactive sodium does not circulate outside of the containment boundary. The system may consist of conventional primary and secondary sodium loops separated by an intermediate heat exchanger or an innovative design may be proposed by the designers. In any case, the reactor core must be protected against potential damage from energetic events such as sodium-water reactions in the heat transport system. This heat transport system shall have sufficient capacity to prevent exceeding acceptable fuel design limits and to maintain conditions of normal operation within the design limits of the ASME Boiler and Pressure Vessel Code (B&PV Code), Section III, Levels A and B. The heat transport system shall be configured to ensure natural circulation capability and to limit sodium inventory loss in the event of a rupture or leak such that the core is not uncovered at any time.

4.9. Shutdown heat removal: A separate and redundant shutdown heat removal system shall be provided. It shall provide for passive, continuous operation and shall be considered safety-significant. This system shall have sufficient capacity to prevent structures from exceeding ASME B&PV Code Section III Level B limits and fuel design limits under normal conditions if the normal heat transport system is not available. It shall provide sufficient capacity to prevent structures from exceeding ASME B&PV Code Section III Level C limits and fuel safety limits under accident conditions within the design basis.

4.10. Instrumentation and control systems: A highly reliable instrumentation and control system capable of maintaining plant conditions within prescribed operating ranges and providing reliable information on plant processes shall be provided. It is expected that the control room(s) and the I&C systems will use digital technology, proven hardware and verified and validated software, and have growth capability to accommodate future hardware and software changes and enhancements. The system shall incorporate self-diagnostic and on-line maintenance features.

4.11. **Data communication and handling:** State-of-the-art systems for communicating and handling plant data shall be provided.

4.12. **Reactivity control:** Two independent and diverse reactivity control systems shall be provided. Each system shall have the capability to ensure that the reactor can be brought to and maintained in a safe shutdown state under all operating and accident conditions within the design basis assuming failure of other systems.

4.13. **Reactor protection system:** An IEEE Class 1E reactor protection system, considered safety-significant, separate and independent from the plant control system, shall be provided to ensure reactor shutdown, prevent fuel damage and prevent structures from exceeding ASME B&PV Code Section III Level C limits under accident conditions within the design basis. The design shall be such as to minimize the likelihood that an operator action can prevent the reactor protection system from performing its safety functions or inhibit the functioning of any passive safety feature.

4.14. **Diagnostics:** Diagnostic systems shall be provided to detect off-normal conditions. Systems for detecting sodium leakage and cladding failures during operation and shutdown shall be provided.

4.15. **Reduce challenges to safety systems:** The plant design shall include reliable equipment for all non-safety functions. If failure of an item of equipment performing a non-safety function can challenge safety-significant systems, the design shall reduce the frequency of such challenges to an acceptable level.

4.16. **Post-accident monitoring:** A system for monitoring safe shutdown conditions shall be provided. It shall be designed to monitor selected system parameters in their anticipated ranges under conditions of normal operation, frequent and infrequent events. The parameters to be monitored shall include those related to the fission process and the integrity of the fuel, reactor coolant system boundary and the containment. This system shall be highly reliable and fault tolerant, and shall be considered safety significant.

4.17. **Equipment qualification:** Safety-significant equipment shall be designed with due consideration of the environment expected to be present when it is called upon to perform its safety function. Possible effects of external events and equipment aging shall be considered.

4.18. **Radiation protection for plant personnel:** The ABR design shall include sufficient shielding and other measures for radiation protection to ensure that radiation levels within and outside the plant are acceptable and that dose to plant personnel is as low as reasonably achievable. The integrated whole-body exposure for workers in routine operations, maintenance and inspection shall meet NRC's requirements. Radiation protection shall be provided to limit individual exposure to within those requirements.

4.19. **Containment:** The ABR design shall include a containment system that provides a low-leakage, safety-significant structure as the final physical barrier against radiological release. The containment system shall also provide sufficient shielding to satisfy radiation protection requirements and serve as a barrier against damage to the reactor from outside attack. The design team shall specify the appropriate codes and standards for design and construction of the containment.

4.19.1. The containment system, including all access openings and penetrations, internal compartments and internal structures shall be designed to accommodate the calculated pressure and temperature conditions associated with normal operation and accident conditions within the design basis without exceeding the design leakage rate. The design shall account for thermal energy sources, such as decay heat, fires and potential exothermic chemical reactions, as well as any mechanical challenges.

4.19.2. The design containment leak rate shall meet NRC's leak rate requirements. The design shall permit periodic leak rate testing and surveillance of the containment boundary in accordance with NRC requirements.

4.19.3. The containment shall satisfy regulatory requirements for physical protection of vital SSCs located within the containment.

4.19.4. In the commercial and **prototype ABR**, the containment shall include hatches and internal spaces that are large enough to allow for removal and replacement of major components such as intermediate heat exchangers and primary pumps.

4.20. **Fuel handling:** The ABR design shall provide for receipt, handling, storage, security, international verification and accountability of fresh fuel entering the facility. Adequate cooling for the fresh fuel shall be provided. Similarly, the design shall provide for handling, storage, security, verification and accountability, cooling, preparation for shipment and dispatch of spent fuel. Suitable equipment for fuel handling shall be provided.

4.20.1. The design shall facilitate control and accountancy of nuclear material throughout its presence in the facility, including receipt and storage of fresh fuel, loading fresh fuel into the reactor, unloading and interim storage of spent fuel, and preparation for shipment and removal from the facility of spent fuel. Appropriate viewing equipment or other means of identifying fuel assemblies in storage and in the reactor shall be provided.

4.21. Inspection and maintenance: The design shall facilitate inspection and maintenance. To the extent possible, systems and components shall be designed so that routine inspection and maintenance can be performed during operation.

4.21.1. The design shall allow for access, viewing, inspection and testing of systems and components, working and lay-down space for component repair or replacement, and to facilitate good housekeeping and contamination control.

4.21.2. An in-service inspection (ISI) program shall be developed that meets the intent of the ASME B&PV Code Section XI, Division 3. The ISI program shall be applied to safety-significant SSCs and shall ensure that the safety-significant SSCs maintain their ability to perform their safety functions. For other SSCs, the design shall include inspection provisions consistent with maintaining safe, operable conditions throughout the plant.

4.21.3. State-of-the-art techniques for inspection and maintenance of SSCs that are under sodium shall be considered.

4.22. Human Factors: The ABR design shall include considerations of human factors and human-machine interface. Automatic control and safety functions shall be provided to reduce the demands on operators. Plant operating procedures and diagnostics shall be automated to the extent needed to facilitate operator actions. There shall be a clear distinction of functions between operating personnel and the automatic systems provided.

4.22.1. The design shall promote the success of operator actions with due regard for the complexity of operator actions required, the time available for action, the physical environment to be expected and the psychological demands to be made on the operator. The need for intervention by the operator involving complex actions on a short time scale shall be avoided to the extent feasible.

4.22.2. The control room design shall incorporate human factors considerations, and shall provide for protection of the operating staff during accidents and external events.

4.23. Waste Minimization and Management: Design of the ABR shall consider minimization of the volume and activity of radioactive waste produced during operation. Suitable facilities shall be included for management of radioactive waste in accordance with applicable regulations. These facilities shall be considered in the safety, reliability and availability assessments of the plant.

4.24. **Decommissioning:** The ABR shall be designed to facilitate decommissioning, and to minimize the waste produced and the radiation hazards associated with decommissioning.

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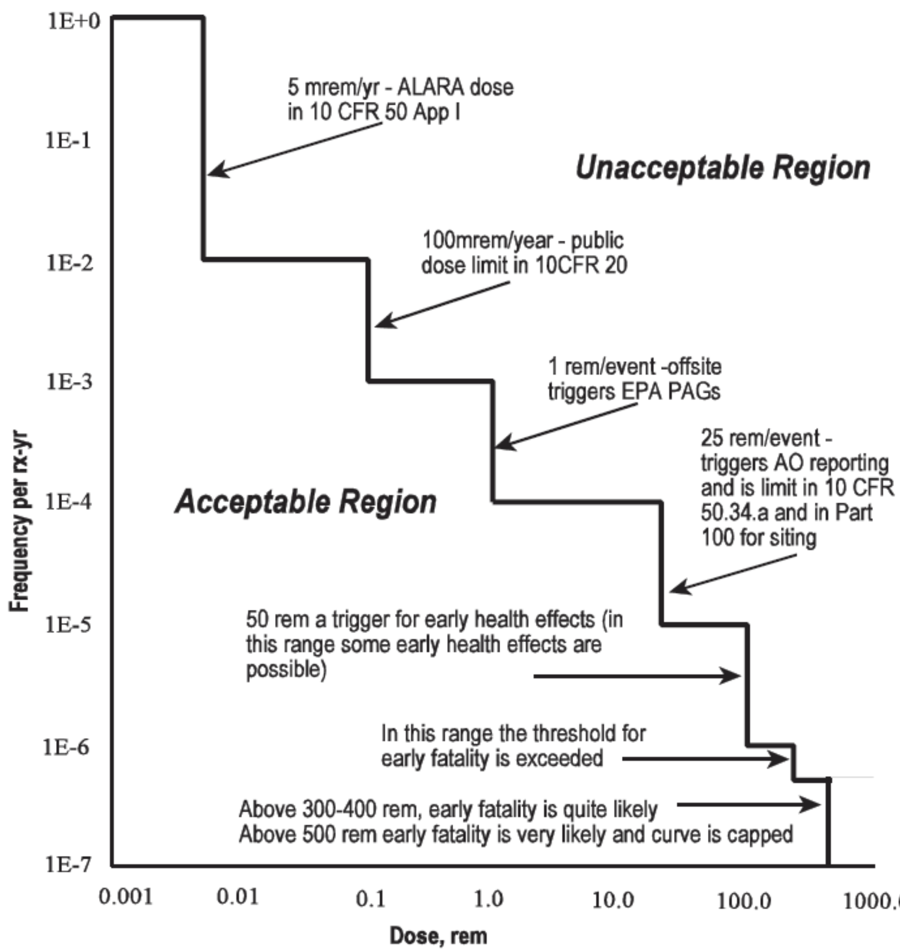
Appendix

A Frequency-Consequence Curve

The frequency-consequence curve shown here was developed by the US NRC and presented in the draft "Framework for Development of a Risk-Informed, Performance-Based Alternative to 10CFR Part 50," NUREG-1860 Working Draft, July 2006.



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