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DOE-STD-1271-2025

August 2025

DOE STANDARD

Authorization Pathway for Nuclear Facilities

U.S. Department of Energy

Washington, DC 20585

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FOREWORD

1. This Department of Energy (DOE) Standard (STD) has been approved to be used by DOE's Office of Nuclear Energy (NE) and its contractors.

2. This Standard implements DOE Policy P 420.2 and P 420.3 and provides a pathway for the authorization by NE of nuclear facilities, including facilities constructed and operated under contract with and for the account of DOE.

3. Beneficial comments (recommendations, additions, and deletions), as well as any pertinent data that may be of use in improving this document, should be emailed to doeid.public.affairs@id.doe.gov or addressed to:

4. This Standard identifies applicable authorization requirements and provides an acceptable methodology for meeting those requirements for NE authorized nuclear facilities.

Contents

1.0 INTRODUCTION

Executive Order 14301 ("Reforming Nuclear Reactor Testing at the Department of Energy") states: (1) "the Secretary shall take appropriate action to revise the regulations, guidance, and procedures and practices of the Department, the National Laboratories, and any other entity under the Department's jurisdiction to significantly expedite the review, approval, and deployment of advanced reactors under the Department's jurisdiction. The Secretary shall ensure that the Department's expedited procedures enable qualified test reactors to be safely operational at Department- owned or Department-controlled facilities within 2 years following the submission of a substantially complete application;" and (2) "The Secretary shall create a pilot program for reactor construction and operation outside the National Laboratories, pursuant to the Atomic Energy Act's authorization of reactors under the Department's sufficient control, including reactors 'under contract with and for the account of' the Department, in accordance with 42 U.S.C. 2140. The Secretary shall approve at least three reactors pursuant to this pilot program with the goal of achieving criticality in each of the three reactors by July 4, 2026."

This Standard identifies a streamlined regulatory pathway to addressing these statements in the Executive Order 14301. This Standard also implements other policy direction to unleash the Nation's nuclear energy potential, including Executive Orders 14154 (Unleashing American Energy), 14299 (Deploying Advanced Nuclear Reactor Technologies for National Security), and 14302 (Reinvigorating the Nuclear Industrial Base). This Standard recognizes the ability of applicants to negotiate in an open dialogue with DOE to achieve safe and secure design, construction and operations in the most efficient method possible using the minimum requirements necessary for this goal. The DOE authorization process reflected in this standard is intended to accommodate efficient and effective leveraging into an NRC license.

This Standard identifies an efficient approach to safety, security, emergency management, and other applicable requirements. This approach will ensure the safety of the public yet provide for more efficient design, construction and operations for NE authorized facilities.

2.0 APPLICABILITY AND SCOPE

This Standard applies to onsite (as defined by DOE P 420.2) and offsite (as defined by DOE P 420.3) nuclear facilities authorized by NE.

This Standard specifies the requirements and responsibilities for engineering/design, safety analysis, operations and interactions essential for the safe design, construction and operation of nuclear facilities, including test reactors, fuel manufacturing and recycling facilities, and major modifications. The Standard also identifies key considerations for the integration of safety into design.

2.1 Applicability

a. Departmental Elements. This Standard applies to all Departmental Elements, and their associated field element(s),[1] to the extent they are involved with facilities and activities described in paragraph 2.1.b.

b. Office of Nuclear Energy Facilities and Activities. Except as stated in paragraph 2.1.d., this Standard applies to all facilities and activities under the responsibility of the Office of Nuclear Energy (NE), including nuclear facilities and nuclear activities authorized by NE. Such nuclear activities include the design, construction, management, operation, decontamination, decommissioning, or demolition of nuclear facilities.

c. Contractors. Except as stated in paragraph 2.1.d., the Standard provides an acceptable pathway to authorization for contractors performing work that involves the facilities and activities described in paragraph 2.1.b.

d. Equivalencies/Exemptions.
    1) Exemption. In accordance with the responsibilities and authorities assigned by Executive Order 12344, codified at 50 United States Code (USC) sections 2406 and 2511 and to ensure consistency through the joint Navy/DOE Naval Nuclear Propulsion Program, the Deputy Administrator for Naval Reactors (Director) will implement and oversee requirements and practices pertaining to this Standard for activities under the Director's cognizance, as deemed appropriate.
    2) Exemption. Activities and facilities subject to regulation by the Nuclear Regulatory Commission (NRC) are exempt from this Standard.
    3) Other Equivalencies/Exemptions. Any other equivalency or exemption to this Standard requires the approval of NE's Safety Basis Approval Authority (SBAA). Requests for equivalencies/exemptions will be adjudicated by NE's SBAA within 14 calendar days of receipt of a substantially complete request.

3.0 ROLES AND AUTHORITIES

- The Office of Nuclear Energy (NE) will fulfil the role of Safety Basis Approval Authority (SBAA) for final and continued authorization of the design, construction, fabrication, assembly and operation of the nuclear facility or activity. The SBAA has the authority to review and approve safety basis and safety design basis documents. The Secretary of Energy will be the Startup Approval Authority (SAA) for new reactors. The Assistant Secretary for Nuclear Energy will be the SAA for other new nuclear facilities. The SBAA will be the SAA for all other startups or restarts (per NE O 425). These authorities may be further delegated as approved by the Assistant Secretary for Nuclear Energy.

[1] Operations offices, service centers, site offices, area offices, field offices, government-owned government-operated facilities, and regional offices of federally staffed laboratories that report directly to a DOE Headquarters office.

- The functions of the Design Authority as previously defined by DOE is "The engineer designated by the Acquisition Executive to be responsible for establishing the design requirements and ensuring that design output documentation appropriately and accurately reflect the design basis. The Design Authority is responsible for ensuring design control and ultimate technical adequacy of the design process. These responsibilities are applicable whether the process is conducted fully in-house, partially contracted to outside organizations, or fully contracted to outside organizations. The Design Authority may delegate design work, but not its responsibilities." For the purposes of this Standard the Design Authority functions are modified as follows:
    - Facility design requirements identified in the Standard and will be negotiated and agreed to by the Contractor and DOE, to the extent permitted by law. Those negotiations will include the applicability of such requirements and the existence of equivalent requirements (e.g. industry standards).
    - The facility design is managed and approved by the Design Authority of the Contractor that is under contract with DOE.
    - Ultimate technical adequacy and final design is approved by NE via approval of the Documented Safety Analysis.
- DOE encourages the Contractor to conduct independent design reviews. Independent design reviews should be conducted by technical experts not responsible for the facility design. These reviews should be open to observation by the DOE Review Team. DOE may use non-DOE experts to supplement its staff, allowing for a more efficient review process.
- To ensure that the public and the workers are protected, DOE may utilize additional resources to supplement the DOE Review Team. This team will be independent of any design or operations of the Contractor and will report to the SBAA/SAA through the DOE Review Team Leader.
- Contractors under a DOE Management and Operating (M&O) contract will be the Design Authority for DOE funded projects. Contractors under an Other Transaction Agreement (OTA) contract will be the Design Authority for those projects.

4.0 BACKGROUND

The nuclear facilities covered by this standard are required to provide reasonable expectation of adequate protection using the principles below to comply with federal law (e.g., the Atomic Energy Act of 1954, as amended [AEA]) regarding the two principles (1) health and safety of the public and co-located workers, and (2) security and protection of special nuclear material.

The first principle is implemented through the following fundamental safety functions:

-Radioactive Material Confinement
-Nuclear Reactivity Control
-Fission and Decay Heat Removal
-Preservation of adequate radiation shielding

The second principle is implemented through the following:

-Physical security
-Perimeter protection
-Access control
-Armed guards (not required if passive engineering controls demonstrate sufficient delay time until an armed response)
-Hardened infrastructure
-Cybersecurity
-Network security
- Intrusion detection
- Vulnerability checks and updates

-Nuclear material safeguards
-Personnel security

These two principles are the statutory foundation upon which federal regulation of private nuclear activities is built. Consequently, DOE authorization requirements are generally limited to this scope. In some instances (e.g. worker industrial safety), DOE authorization is exempted from other federal requirements (i.e. Occupational Safety and Health Administration requirements). To the extent DOE imposes requirements beyond this foundation, those requirements should be consistent with standard industry practices. Ensuring compliance with these requirements is the responsibility of the contractor and is implemented with engineering, quality, safety, and security programs using a graded approach based on material at risk. The Design and Authorization Integration Process in the section below outlines an acceptable pathway to comply with applicable requirements and receive DOE authorization.

5.0 TERMINOLOGY

Shall, Should, Must and May – Traditionally, the word “shall”/”must” denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes a discretionary action that is neither a requirement nor a recommendation. The Contractor may propose alternatives to the requirements in DOE directives and standards. These will be proposed to the SBAA for approval.

6.0 DESIGN AND AUTHORIZATION INTEGRATION PROCESS

The simultaneous integration of design, safety analysis, regulatory review, and feedback in nuclear facilities is crucial for several reasons:

1. **Clarity**: Integrating these processes ensures that all stakeholders have a clear understanding of the requirements and expectations. This clarity helps in aligning the design with safety standards and regulatory requirements from the outset, reducing the likelihood of misunderstandings or misinterpretations later in the project.

2. **Efficiency**: By integrating these processes, the project can progress more smoothly and efficiently. Early identification and resolution of potential issues can prevent costly delays and rework. This approach allows for a more streamlined workflow, where design adjustments can be made in real-time based on safety analysis and regulatory feedback.
3. **Regulatory Stability**: Simultaneous integration fosters a stable regulatory environment by ensuring that the design and safety analysis are continuously aligned with regulatory requirements. This stability is essential for maintaining public trust and ensuring the long-term viability of nuclear projects. It also facilitates a more predictable and transparent regulatory review process, which can expedite approvals and reduce uncertainties.

To facilitate this integration, key stage gates are essential to project success based upon Department of Energy experience in successful and non-successful new facility deployment activities. These stage gates are highlighted in Figure 1 (below) and discussed later in this section. It is expected that the regulatory submittals associated with each stage will be performed sequentially, given the increasing level of design detail included in each and the need for agreement on earlier items to support review and approval of subsequent items. Close coordination between the Contractor and DOE can facilitate expeditious completion and approval of each submittal.

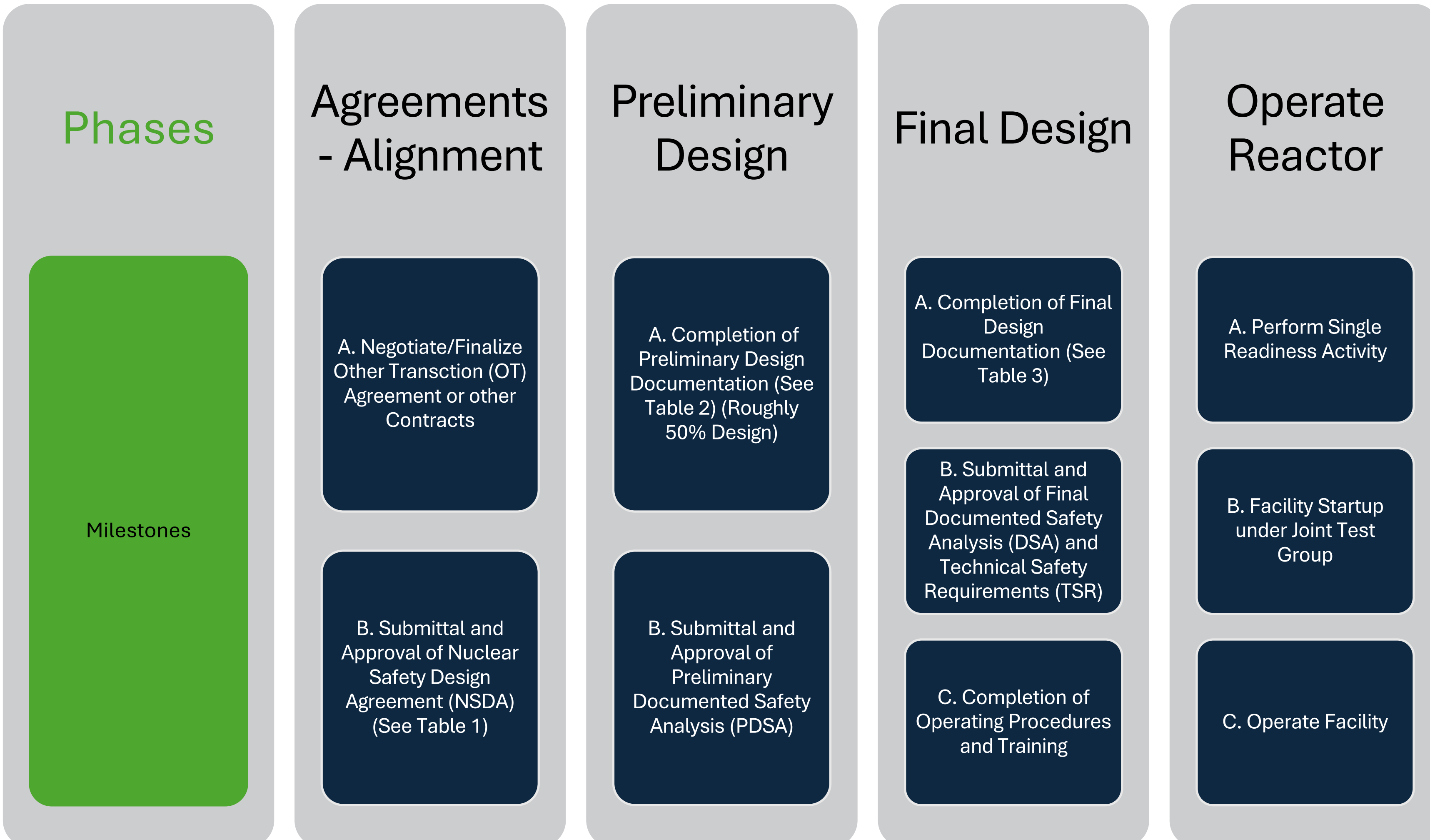

Figure.1: Summary of DOE Authorization Process for Nuclear Facilities

Notes – Agreements - Box B represents a streamlining of past DOE expectations in that it eliminates precursor steps to a PDSA. For nuclear facilities that are funded by private entities, construction may start at the earliest point permitted by law. Nuclear material, over a Hazard Category 3 level, may not be added to the nuclear facility until the Readiness Review is completed and approval of the Startup Approval Authority is obtained. See NE O 425.1

7.0 AUTHORIZATION PROCESS

7.1 Contracts and Agreements

7.1.1 Contracts

The first step in the authorization process is for the applicant to negotiate and sign a contract with DOE. DOE, or a DOE M&O Contractor will receive an application from a commercial vendor and DOE will begin negotiating the necessary contractor terms and conditions needed to protect the co-located worker and public from fission product release and radiation exposure, and to maintain physical security and criticality safety of nuclear material. For the purposes of this Standard, the Contractor will be responsible for compliance with all DOE requirements negotiated between DOE and the Contractor, the baseline of the requirements starting from Attachment 2 of this Standard and flowing down to any applicable requirements to their subcontractors or partners through appropriate agreements. The purpose of the agreements and alignments activity is to ensure proper establishment of expectations and authorities
The agreements and/or contract should consider the following topics:

- Siting requirements and leasing agreements
- Roles and responsibilities of DOE and Contractor
- Nuclear Fuel Source, Ownership and Possession
- Determination of Funding Mechanisms and Responsibilities
- Review Roles and Expectations (e.g. level of DOE technical support resources that will be available to contractor versus contractor-provided resources to support DOE reviews.)
- Required permits as applicable under the Federal Facilities Compliance Act
- Applicable DOE and other federal/state/local requirements and orders
- Intellectual Property and Marking
- Responsibilities and Liabilities for Decommissioning and Disposition of Wastes

7.1.2 Nuclear Safety Design Agreement (NSDA)

NE and the Contractor must come to early agreement on the applicable requirements. The purpose of the Nuclear Safety Design Agreement (NSDA) is to gain agreement on design requirements, safety analysis approach, regulatory engagement process, applicable regulatory requirements, and to identify the key safety decisions for the design. Additionally, it discusses the designer's planned application of codes and standards included in the Code of Record. The required technical content to be identified and documented in the Agreement are identified in Table 1 below. At this stage of the process the concept of operations is not required to be fully detailed for every activity and action, however it needs to describe the full scope of proposed activities to be performed under DOE authorization and a notional concept of how the Contractor proposes that those activities be performed. This is to support alignment on the proper regulatory requirements and avoid expectation misalignment in order to avoid additional costs and project delays.

Table 1: Selection and Content Guide for Nuclear Safety Design Agreement (NSDA)	
Section	**Description**
Project Purpose and Design	Outline the high level functional and performance objectives. Outline the lifecycle concept of operations.
Safety Analysis Preparations	Fundamental Safety Function identification for design and notional allocation of structures, systems, and components (SSCs) proposed to be utilized for satisfying them to the extent known at this point. Outline the hazard and accident analysis process, identifying potential hazards and accidents and their mitigation measures. Identification of process for confirmation of adequate analysis results including software quality assurance and plan for confirmatory analyses.
Safety Document Format and Content	Identify the approach for format and content of the Preliminary Documented Safety Analysis (PDSA) and the Documented Safety Analysis (DSA). This may include the application of existing standards or development of an individualized approach.
Regulatory Engagement Process	Detail the regulatory engagement process, including interactions with the DOE and other regulatory bodies and how safety requirements will be identified, integrated into the design and verified. Identify applicability and areas of equivalency for regulatory requirements. Outline the documentation process, including the submission and approval of the NSDA, PDSA, and DSA. Detail the engagement process with the DOE Review Team, encouraging frequent meetings to discuss the status of the design and future operations.
Key Safety Decisions for the Design	Highlight key safety decisions, such as the target performance of SSCs, safety system responses to normal and off-normal operations, and security of the facility. This will include a discussion of any significant safety issues or attributes of the design which will need clarity such as but not limited to; use of qualified fuel types, monitoring requirements, safety limits and required staffing.
Safety SSC Classification Rules and Terminology	Define the classification rules and terminology for safety SSCs, including the application of the hierarchy of controls and Defense in Depth to ensure safety.

Authority to Confirm and Make Safety Decisions	Identify the contractor authority or process responsible for confirming and making safety decisions.
Dose Consequence (Unmitigated or MHA Style)	Include an analysis of the most limiting potential dose consequences (e.g. unmitigated or Maximum Hypothetical Accident (MHA) style scenarios) to support Natural Phenomena Hazard (NPH) Design Category (NDC) categorization, validity of selected safety document format and content, applicability of SSC classifications and other graded approaches.
Natural Phenomena Hazard (NPH) Design Categorization	Establish Criteria for NPH Design, such as NDC categorization based upon a bounding dose calculation.
Code of Record – Applicability and Equivalencies	Provide a Code of Record (as an attachment or reference in the NSDA). At the NSDA phase the Code of Record is likely not complete but it must: (1) Include a table detailing the applicability of industry codes and standards to the design at a system level; and (2) Address the potential need for code variances, equivalencies, and exemptions to the extent known, and state the planned or proposed justification, ensuring the design meets the intent of the applicable regulatory requirements.
Engineering Process and Requirements Flow down	Outline the engineering process to be utilized to track requirements, verify that the design has satisfied the requirements, and communicate the design to DOE for regulatory review and development of the operational baseline. Document the framework for when various elements of the design will be placed under configuration management and the means to ensure notification to and approval by DOE for changes which may impact previous DOE approvals.

7.1.3 Code of Record

The Code of Record (COR) is a listing of codes and standards determined by the design organization to be applicable to the design. Where a code or standard is deemed generally applicable but exceptions to the code or standard provide a better approach, the COR should identify the exceptions taken and provide reference to the technical evaluation demonstrating the alternative approach provides equivalent or better safety compared to the applicable code.

The COR is initially developed in support of the NSDA remains a reference in both the PDSA and the DSA and is provided for DOE review and approval with each submittal. The COR shall be updated throughout the design process and shall be placed under configuration control at Preliminary Design to ensure consistency with the final authorized design. DOE approval of the various safety basis deliverables signifies concurrence with the COR and associated exemptions or equivalences provided as references.

7.2 Preliminary Design

The Preliminary Design specifies processes, structures, systems and components with reasonable confidence of satisfying all design requirements and particularly design requirements related to provision of safety functions. At Preliminary Design, systems are identified, components are selected, sized, and supported with preliminary analysis, interfaces are identified and controlled, and verification methods are planned. A Preliminary Design Review may be conducted to elicit input and confirmation of the approach from interested parties, including DOE.

7.2.1 Preliminary Design Details and Maturity

Table 2 describes typical design maturity at completion of Preliminary Design.

NOTE: The noun "document" used in the design process denotes a controlled record, whether paper or electronic, whether in the form of a drawing, model, file, or database. As a verb, "document" means to create and control such a record. The word does not imply any particular technology, method, or format.

Table 2: Preliminary Design Maturity		
Activity or Deliverable	**Status**	**Verification Status**
Code of Record	Preliminary, Controlled[1]	Verified
Master Document List	Preliminary, Controlled	Verified
Design Requirements	Preliminary, Controlled	Verified
Concept of Operations	Updated from Nuclear Safety Design Agreement	None
Hazard Analysis	Preliminary, Controlled	None
Accident Analysis	sequences and conditions identified, scoping[2] analysis drafted	None, confirmatory analysis, if any, identified
Safety Classification of SSCs (Safety Credited Equipment List) and safety	Controlled	None

[1] Controlled means the artifact has been reviewed, approved, and documented in a retrievable manner

[2] Scoping means that issues judged to be of greatest importance have been addressed in at least an approximate manner

functions and performance criteria identified		
System and Component designs documented	Initiated, each design 50% complete	None
System performance analysis and calculations demonstrating safety functions are satisfied in accordance with established performance criteria	Scoping	None, confirmatory analysis, if any, identified
Component performance, selection, and sizing basis	Scoping	None, confirmatory analysis, if any, identified
System configuration showing layout, sizing, spacing, clearances	Draft[3]	None
Software design specification	Draft	None
System Design Descriptions	Draft	None
Qualification Test Plans	Components and systems identified; general test methods identified	None

7.2.2 Preliminary Documented Safety Analysis (PDSA)

The purpose of a Preliminary Documented Safety Analysis (PDSA) is to provide a comprehensive and preliminary assessment of the safety aspects of a nuclear facility or activity. The Contractor submits the PDSA to DOE for review and approval once the necessary analyses and system design detail has been performed (nominally the 50% design completion mark) and is provided in the format outlined in the NSDA. The significance of the PDSA is that it represents the first formal opportunity to look at the proposed design, safety case and associated SSC performance and classification requirements in an integrated manner. Review and approval of the PDSA by DOE provides DOE with an integrated perspective on the safety and performance of the facility as well as a set of performance requirements for systems which will satisfy the associated regulatory requirements. Conversely for the Contractor, approval of the PDSA by DOE reflects confidence that the proposed approach is deemed acceptable, establishes regulatory certainty on the proposed approach and supports subsequent procurement actions by clearly establishing performance requirements on the key SSCs necessary to ensure safety of the overall facility. As a result, after PDSA approval it is expected that the Contractors Configuration Management program assesses design changes to ensure that any changes which may affect the facility as approved in the PDSA are properly identified and evaluated. In the event that those changes affect the commitments in the PDSA, they must be reviewed and approved by DOE.

[3] Draft is a notionally complete but unverified product based on an evolving state of design maturity

The approved format in the NSDA should ensure that the PDSA clearly reflects that the following elements have been addressed:

1. **Facility Description and Reference to Preliminary Design Documentation**: This section should provide sufficient detail to understand the design and operations in support of evaluating the adequacy of the safety case.
2. **Hazard and Accident Analyses**: This includes the methodology for hazard analysis, results of the hazard analysis, accident identification methodology, accident selection, analysis of design basis accidents, and beyond design basis accidents.
3. **Safety Structures, Systems, and Components (SSCs)**: Identification and classification of SSCs necessary to protect the public and workers, including definition of safety functions, functional requirements, performance criteria and environmental qualification requirements.
4. **Analyses Methodologies**: Justification of the analysis tools and methods to be used for confirming adequacy of the design and safety analysis.
5. **Approach for Safety Management Programs**: Summarizing the approach for safety management programs and the path to full implementation by DSA.

7.3 Final Design

Final design is achieved when the reactor or facility is substantially complete through construction, fabrication, and assembly. Design changes, including accepted deviations and nonconformances, made following preliminary design and throughout construction, fabrication, and assembly have been evaluated and incorporated into as-built design documents or fabrication files as appropriate.

7.3.1 Final Design Details and Maturity

Table 3: Final Design Maturity

Activity or Deliverable	Status	Verification Status
Code of Record	Final, As-built, Controlled[4]	Verified[1]
Master Document List	Final, As-built, Controlled	Verified
Design Requirements	Final, As-built, Controlled	Verified
Concept of Operations	Updated from Preliminary Design	Verified
Hazard Analysis	Final, As-built, Controlled	Verified
Accident Analysis	Final, As-built, Controlled	Verified, Confirmatory analysis complete
Safety Classification of SSCs (Safety Credited	Final, As-built, Controlled	Verified

[4] Controlled means the artifact has been reviewed, approved, and documented in a retrievable manner

Equipment List) Identifying Safety Functions and performance criteria		
System and Component designs documented	Final, As-built, Controlled	Verified
System performance analysis and calculations demonstrating safety functions are satisfied in accordance with established performance criteria	Final, As-built, Controlled	Verified, Confirmatory analysis complete
Component performance, selection, and sizing basis	Final, As-built, Controlled	Verified, Confirmatory analysis complete
System configuration showing layout, sizing, spacing, clearances	Final, As-built, Controlled	Verified
Software design specification	Final, As-built, Controlled	Verified
System Design Descriptions	Final, As-built, Controlled	Verified
Qualification Test Plans	Executed, dispositioned, controlled	N/A

Note: 1. Verified activities will be checked for completeness and accuracy as part of the DOE review. Issues and comments will be made in writing to the contractor if needed.

7.3.2 Final Documented Safety Analysis (DSA)

The purpose of the final documented safety analysis (DSA) is to establish the safety basis and operating controls necessary to safely operate the facility and validate that the identified design has met those criteria. The DSA is required to be developed by the Contractor, approved by DOE and implemented prior to the initiation of the readiness activities. It incorporates the as built facility, with the expectation that any deviations from the as built facility and the DSA have been appropriately evaluated and documented to not adversely impact the analyses or controls in the DSA through the Unreviewed Safety Question or similar process.

The format and technical content of the DSA are agreed upon by the Contractor and the DOE as part of the NSDA. Approval of the DSA by DOE indicates acceptance of the proposed design and safety case and a determination that the design is suitably safe and compliant to support operations. When coupled with evidence of Contractor preparedness for operation for readiness, and once approved and implemented, DSA provides the authorization to operate the nuclear facility.

7.3.3 Safety Management Programs and Operating Procedures

Safe operation of the facility is achieved by operating the facility in compliance with the design limits as outlined in the engineering design and the approved safety analysis. These operations are performed in accordance with contractor approved procedures and supported by the specific safety management programs designed to facilitate specialty work as described in the relevant DOE requirements and the approved safety basis. The DSA submittal will be supported by finalized safety management program submittals.

8.0 DOE REVIEW PROCESS

DOE will review the Contractor's NSDA, PDSA and DSA submittals and ensure that each document represents a technically sufficient product based upon the requirements identified in this Standard prior to acceptance for review.

The DOE Review Team standard for review will be 45 days from formal acceptance of the safety basis document (i.e. the NSDA, PDSA, or DSA as applicable) to approve or provide significant comments. It is encouraged that the nuclear facility Contractor maintain close coordination with DOE to ensure quick resolution of questions, significant concerns by DOE, or any misinterpretation by DOE of the submittal.

The DOE Review Team will ensure adherence to the requirements discussed in this Standard, as well as agreed upon requirements proposed by the Contractor and approved in the NSDA. As the NSDA evolves through the design process the DOE the DOE Review Team Lead will brief the review team on the regulatory changes.

DOE will limit its comments to issues that impact the safety of the public or the workers (almost always if the public and workers are protected, the environment is protected). To promote efficient and timely reviews, draft comments may be provided to the Contractor for early resolution. Questions can be provided by the DOE Review Team when draft comments are provided to the Contractor.

There can often be misinterpretation of the intent of the regulatory requirements. If this occurs, the Contractor is encouraged to meet with the DOE Review Team to resolve the difference(s). The Safety Basis Approval Authority is the final arbiter of the intent of the regulations.

The Contractor is encouraged to meet with the DOE Review Team frequently to discuss the status of the design and future operations. It is expected that the Contractor will invite the DOE Review Team to design reviews. The DOE Review Team will participate as observers only, reserving questions or comments if there is a clear deviation from a requirement.

A Safety Evaluation Report will be prepared using the guidance of DOE-STD-1104 and approved by the Safety Basis Approval Authority.

9.0 FACITLITY STARTUP AND TRANSITION TO OPERATIONS

9.1 Readiness Review

The purpose of the DOE Readiness Review is to confirm capability for safe startup and operation of a nuclear facility. The DOE Readiness Review involves review of a multi-disciplinary team to ensure that facility procedures and staff training are adequate to support safe operation, that the facility and equipment have been established consistent with the approved design, that safety equipment functions correctly and that the safety management programs identified in the agreements have been implemented as required.

Satisfactory completion of the DOE Readiness Review results in DOE issuing Startup Approval which allows for nuclear operations in the facility to commence in a controlled manner consistent with the startup plan.

9.2 Initial Start-up Testing/Joint Test Group

Initial startup and commissioning of a new or significantly modified DOE nuclear facility will be performed under the direction of a startup or commissioning plan. The plan must ensure the safe startup of a nuclear facility, such as a test reactor. It involves verifying that all systems and components function as intended and meet safety requirements. This plan will outline the necessary steps and tests to ensure that unrestricted facility operations can be performed safely. This includes specific plant tests, performed in a staged manner that start at the lowest hazard activities and demonstrate the functionality of the full facility with a focus on the performance of the safety systems and the validity of the safety analyses. The Contractor provides the startup and commissioning plan in conjunction with the submittal of the DSA. The appropriate hold points and levels of approval to move past those hold points are recommended by the Contractor and approved by the SBAA. After completion of the Readiness Review and Startup Approval, the test plan is performed by the facility under the direction of the Joint Test Group (JTG).

The purpose of a JTG is to ensure the safe and efficient startup of a nuclear facility. This group is responsible for overseeing the initial startup testing, which includes verifying that all systems and components function as intended and meet safety requirements and that the key behavioral predictions in safety analyses are correct as demonstrated in the actual operating plant. The JTG plays a crucial role in identifying and resolving any issues that may arise during the startup phase, ensuring that the facility operates safely and effectively from the outset.

The JTG is composed of key stakeholder organizations, including operations, systems and reactor engineering, nuclear safety and a representative from DOE, and is supported by other subject matter experts as necessary. This diverse composition ensures that all critical aspects of the facility's startup are thoroughly reviewed and managed. The requirements for participation on the JTG include a thorough understanding of the facility's design, safety analysis, and operational procedures. Members of the group must be well-versed in the technical aspects of the facility and possess the necessary expertise to evaluate its performance. Additionally, the group must work closely with senior management within both the Contractor and the DOE to ensure compliance with all applicable standards and regulations. This collaboration is essential for achieving a successful and safe startup of the nuclear facility.

9.3 Facility Operations

Both the Readiness Review and Initial Startup activities are designed to ensure that the Contractor demonstrates the capability to operate the facility in a manner consistent with the safety basis and that the performance of the operating system is consistent with the safety analysis and operating controls. After successful completion of the readiness review and the initial startup plan, the Contractor is authorized to operate the facility for the designated mission and facility objectives in accordance with the approved DSA and technical specifications without needing to request DOE permission for approved activities. The activities remain subject to ongoing DOE oversight as defined by the applicable requirements of the DOE contract and governing federal laws and regulations.

ATTACHMENT 1: APPLICABLE DOE ORDERS, STANDARDS, AND NRC AND INDUSTRY EQUIVALENTS

The Contractor should use the following DOE Orders and Standards subject to the considerations below in its submittal of the final Documented Safety Analysis. Except where noted, the Contractor may also use any equivalent US Nuclear Regulatory Commission (NRC) regulation/guide or industry standard. The Contractor may also request a self-generated equivalent requirement in lieu of the requirements and standards below, or request an exemption. Requests for self-generated equivalences or exemptions will be adjudicated by SBAA.

Emergency Management

NE O 151.1 Comprehensive Emergency Management System which references Presidential Policy Directive 8 (PPD-8) and Homeland Security Presidential Directive 5 (HSPD-5), including adoption of the National Incident Management System.

Oversight and Response to Events

DOE organic statutes and implementing regulations require DOE to assure the safety and health of the public and protect the environment. DOE orders and technical standards provide a method of compliance. However, DOE recognizes that there may be alternative methods of compliance. To that end, the Contractor may choose to include in the DSA submittal either the requirements listed below or an alternative method of compliance such as an industry or other regulatory standard, unless otherwise stated.

NE O 225.1 Accident Investigations

NE O 226.1 Implementation of Department of Energy Oversight Policy

NE P 226.1 Policy for Federal Oversight and Contractor Assurance Systems

NE O 227.1 Independent Oversight Program

NE O 231.1 Environment, Safety and Health Reporting

NE O 232.1 Occurrence Reporting and Processing of Operations Information

DOE O 442.1B Department of Energy Employee Concerns Program -No alternative standard is allowed.

DOE O 442.2 Differing Professional Opinions for Technical Issues Involving Environmental, Safety, and Health Technical Concerns -No alternative standard is allowed.

DOE P 451.1 National Environmental Policy Act Compliance Program

DOE-STD-1104-2016 Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents. This standard is for Federal staff use only and may be tailored to meet the authorization process outlined in this standard. Review Plans and Safety Evaluation Reports, as well as Safety Review Letters, may also be tailored consistent with the safety document being reviewed.

Nuclear Safety, Quality and Radiation Control

The Contractor may choose to include the requirements listed below or propose to utilize an alternative industry or other regulatory body standard.

NE O 414.1 Quality Assurance

NE O 420.1 Facility Safety

NE O 422.1 Conduct of Operations

NE O 458.1, Radiation Protection of the Public and the Environment

NE-STD-1020-2025, Natural Phenomena Hazard Analysis and Design Criteria for DOE Facilities

NE-STD-1027-2025, Hazard Categorization of DOE Nuclear Facilities. (The SBAA may approve a lower facility hazard classification depending on the degree to which a reactor or non-reactor facility proses a hazard to the worker or the public).

DOE-STD-1237-2021, Documented Safety Analysis for DOE Reactor Facilities

DOE-STD-1628-2013, Development of Probabilistic Risk Assessments for Nuclear Safety Applications.

DOE-STD-3009-2014, Preparation of Nonreactor Nuclear Facility Documented Safety Analysis. This standard may be implemented in part or whole for existing facilities that are using DOE-STD-3009-94. The SBAA may recognize exceptions within this Standard. (e.g., Chemical hazards without a nexus to a nuclear event are not required to be analyzed.)

Operations

The Contractor may choose to include the requirements listed below or an alternative industry or other regulatory body standard.

NE O 425.1 Verification of Readiness to Startup or Restart Nuclear Facilities

NE O 426.1 Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities

NE O 433.1, Maintenance Management Program for DOE Nuclear Facilities

DOE-STD-1073-2016, Configuration Management

Security

To meet the requirements of the Atomic Energy Act of 1954, as amended, and other DOE organic statutes, the Contractor may choose to include the requirements listed below or an alternative industry or other regulatory body standard.

NE O 470.1 Office of Nuclear Energy Security Program

Transportation

The Contractor may choose to include the requirements listed below (as revised) or an alternative industry or other regulatory body standard.

DOE O 460.1D Chg 1 Hazardous Materials Packaging and Transportation Safety

DOE O 460.2B Departmental Materials Transportation Management

DOE O 461.1C Chg 1 Packaging and Transportation for Offsite Shipment of Materials of National Security Interest

DOE O 461.2 Onsite Packaging and Transfer of Materials of National Security Interest

Waste Management

The Contractor may choose to include the requirements listed below or an alternative industry or other regulatory body standard.

NE O 435.1 Radioactive Waste Management

DOE M 441.1-1 Nuclear Material Packaging

Information Technology/Cyber Security

To allow for enhanced flexibility and unique mission capabilities, some systems and data authorized by NE may not be classified as federal information. An Interconnection Security Agreement (ISA) is mandatory for connectivity to the INL for all programs or activities requiring access approval, including integrated vendor solutions. For contractors offsite, an ISA is also necessary for any interconnection or data shared with DOE or the INL. All contractors approved must adhere to best industry practices where possible to support Information Technology (IT) governance, ensuring the resilience of all associated systems and data, and upholding necessary safety and security requirements. Related approval documents should explicitly define the security standards used and associated cybersecurity requirements addressed, to include instances where standards or requirements have been reduced or eliminated, as necessary.

DOE O 471.6 Chg 4 Information Security

DOE O 471.7 Controlled Unclassified Information

DOE O 475.1 Counterintelligence Program – For contracts offsite, NE will coordinate with the Office of Counterintelligence regarding consultation and management of the Contract Requirements Document in this Order. Contractors offsite will coordinate with NE and the Office of Counterintelligence regarding investigations.

DOE O 475.2B Identifying Classified Information - Contractors offsite must identify if they will generate classified information as the initiation of the contract. If the determination is made that there will be classified information, they will be subject to this DOE Order.

DOE O 486.1A Foreign Government Sponsored or Affiliated Activities

DOE O 471.1B Identification and Protection of Unclassified Controlled Nuclear Information

ATTACHMENT 2: ADDITIONAL GUIDANCE FOR TEST REACTORS

Contractor incorporation of the guidelines below will assist the Office of Nuclear Energy in its review of safety analysis documentation.

Use of Qualified Fuel Type

NE encourages the use of previously qualified fuels with a proven operating history. Fuel qualification is a very important step in the assurance of adequate protection for reactor designs. Use of TRISO (1), TRIGA (2), EBR-II Na-bonded fuel (3), and others manufactured under a qualified process provides assurance that fundamental safety features can be met.

NE understands that some reactor designs may need to deviate slightly from qualified designs and manufacturing processes based on reactor design constraints. In this case, the fuel could be subject to the expectations of a formal qualification program (e.g. NUREG-2246), the deviation may be slightly outside processes and acceptance variables and a case for monitoring for fission breaks (4) in real time with a condition that if primary coolant activity went above an acceptance threshold, the reactor would be shut down, until an assessment of the situation and cause determination was performed.

Qualified fuel subject to operating conditions outside the qualified operating range will also be subject to active fission break monitoring.

Notes:
(1) qualified and manufactured for example under the AGR-1/2 processes (EPRI Report)
(2) procured under license from Framatome
(3) manufactured using the process and specifications from EBR-II
(4) Fuel outside of qualified fuel forms and associated operating parameters will be subject to the active monitoring for fission breaks (fuel failure)

Safety Limits

10 CFR 830 defines Safety limits (SLs) as the limits on process variables associated with those safety class physical barriers, generally passive, that are necessary for the intended facility function and that are required to guard against the uncontrolled release of radioactive materials.

SLs for reactor facilities should be established to protect the integrity of the principle physical barrier that guards against an uncontrolled release of radioactive material. For reactor facilities, this physical barrier is often the fuel cladding. SSCs protecting reactor facility SLs will be designated consistent with the specified safe harbor methodology.

SLs may be imposed by the SBAA.

Autonomous Operation

Given the inherent safety features of advanced nuclear facilities, reduced operational staffing levels may be appropriate to improve their economic viability. A key enabling technology for this purpose is autonomous control that enables autonomous operation of such facilities. Autonomous operation may rely on technologies such as artificial intelligence and machine learning to monitor facility operations and make adjustments with minimal human intervention. This is distinct from automatic operation, which implements a relatively simple and static set of rules and parameters provided by a human designer or operator.

Autonomous control should not be perceived as a single feature that when added delivers certain new unanalyzed functions. Autonomous control capability is a highly complex systems engineering process that requires detailed understanding of system dynamic response as a function of operational actions. These advanced capabilities can be achieved at different levels of autonomy, which would then require different levels of human operator involvement in operational decision making. Several options exist for autonomous control ranging from simple automation of some procedures to fully autonomous operational mode with automatic decision-making and execution without the involvement of a human operator, as well as the ability for machine learning of facility process parameters.

The division of functions and responsibilities between the human operator and the automatic control system is important to clarify early in the design and safety analyses process. The operational range or envelope possible under autonomous control needs to be considered during design verification and safety analysis, and human operators need to be trained to supervise and respond in all allowed operational states.

For reactors, simple, fail-safe means must be provided for the operator to place the reactor in a safe shutdown state at any time, with independent and diverse control of a system or manual scram actuation. For example, the operator must have access to a reactor trip button from outside the reactor room that initiates a reactivity control mechanism not subject to autonomous control to initiate safe reactor shutdown.

Requirements for Autonomous Control of Small Reactors

- The nuclear facility (reactor) including communications with any needed remote monitoring or operations location will meet the requirements of the Department of Energy (DOE) Order 205.1D – Department of Energy Cyber Security Program including the Office of Nuclear Energy Program Cyber Security Plan which further delineates cyber security within the Office of Nuclear Energy. This will be agreed upon early in the design and approved by the NE Safety Basis Approval Authority. The facility Information Technology and Operational Technology system will have specific security plans that document the cyber security requirements.

- A Concept of Operations (or equivalent) will be developed and maintained through the systems engineering lifecycle that describes how operations in autonomous control will occur.
- The Concept of Operations will include a test plan to increase the amount and extent of autonomous controls incrementally from minor operational control to the full extent of the autonomous design.
    - Each increase in autonomous control will include testing which will validate the design, safety analysis and operations procedures.
    - It is recommended that simulations with operations and engineering staff be conducted prior to initial operations of the reactor and prior to each phase of the test plan. Where startup testing on the actual reactor does not allow sufficiently refined incremental increase of autonomous control, these simulations are required.
    - Human Factors will be incorporated into the Concept of Operations Plan. This will include clear warnings and clear manual interventions that operators will take in the event of autonomous control failure, compromise, anomalies, or plant conditions challenging safety controls.
    - Procedures will be developed and systems provided for operator manual control at minimum to achieve cold shutdown.
    - Operators, Engineering staff and Management will be trained on the Concept of Operations Plan.
    - The autonomous control must have the ability to accept operator commands and incorporate and give precedence to those commands along with other control decisions.

- The autonomous control must have complete physical separation from the reactor protection systems and noninterference with any safety-related function. Shared-use signals from common detectors are acceptable provided the design precludes any effect of the autonomous system on the signal used for plant protection.
- The operating envelope available to the autonomous control must not be able to violate the fundamental safety functions of the design of the nuclear reactor that protect the primary fission product containment layer, decay heat removal, reactivity control for shutdown and hold down, and shielding.
    - Except for shared one-way detector signals as described above, safety systems shall be independent of plant control systems. In addition to conventional design requirements, safety systems will be stand-alone, physically, and logically separated and air gapped from the autonomous control system.
- Autonomous operation should have a watch dog timer for continued assessment by the reactor operator. The operator on watch shall be near enough to physical hardwired controls to respond to any anomaly of the autonomous control detected by the watchdog timer with sufficient time margin to ensure reactor safety.
- The Technical Safety Requirements will include a Programmatic Administrative Control that documents the requirements for use of autonomous controls. Additional requirements related

to autonomous control may be identified as specific administrative controls and/or as functional requirements/performance criteria for safety structures, systems, or components.

- Defense-in-depth strategies and systems will be analyzed for autonomous control systems.
- The Technical Safety Requirements will identify all operational modes that allow autonomous control.
- Reactor system dynamics will be analyzed to ensure that the autonomous control system provides acceptable response times for decision-making.
- The decision algorithm generates the same output for a given set of inputs and does not violate reactor control limits.
- Except for parameters that are adjusted by machine learning, the internal state or the memory of the decision algorithm should not have an impact on the output. The control shall be deterministic.
- Instrument or indication uncertainties shall be considered in the decision-making algorithm.
- The decision-making algorithm will be tested that ensure system reliability. Tests must ensure that unanticipated transitions that violate the safety rules and operational principles are not initiated by the autonomous control, either acting independently or in response to operator commands.
- There will be a mechanism for documenting the decision logic for autonomous control in a manner comprehensible to the operator. Parameters adjusted through machine learning shall be logged and reviewable. A traceable path from indication, through control logic, to actuation and feedback shall be documented for building trust in the autonomous operations and control system.
- Remote operations require that communications between the reactor instrumentation and controls and some central monitoring facility are secure in the data/information flow across the channel and limit the ability of a malicious actor to damage or compromise the reactor system.
- Autonomous operation of the nuclear facility must be independent of safety control and shutdown systems.
- The autonomous control system will meet the requirements of NE Order 414.1, *Quality Assurance,* including for software Quality Assurance.
- The autonomous control system will be incorporated into the reactor design.
- The autonomous control system does not meet the threshold to be considered a safety system, but there is additional risk that should be taken into account in the classification of the software. The risk is in the use of a new technology in the autonomous control of a nuclear reactor.

Intentionally Challenging an Active Safety System

Intentionally challenging an active safety SSC is an activity that places the facility/equipment in an off-normal condition which requires the active safety SSC to actuate to prevent or mitigate an unsafe condition. An intentional act such as maintenance or testing, which requires an active safety SSC to actuate to prevent exceeding an actual facility safety limit is unacceptable. Testing an active safety SSC is different from intentionally challenging an active safety SSC in that the test procedure simulates an input condition often times when the equipment is not required to be operable.

Intentionally challenging an active safety SSC during normal operations changes the accident frequencies associated with all accident scenarios that involve a failure of the system being challenged. Intentionally challenging an active safety SSC due to an off-normal condition, and requiring the safety SSC actuation to prevent or mitigate an unsafe condition, results in an increase in the probability of an accident involving the failure of the safety SSC and should be considered a positive Unreviewed Safety Question. Therefore, intentionally challenging an active safety SSC outside of approved surveillance testing or approved procedure requires Safety Basis Approval Authority (SBAA) approval.

Reactivity Control for Shutdown

In general, a minimum of two independent and diverse reactivity control systems should be considered: A means of reactivity control shall be provided for: (1) inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the design limits for the fission product barriers are not exceeded and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences. (2) A means for holding the reactor shutdown under conditions which allow for interventions such as fuel loading, inspection and repair shall be provided. If a single control has sufficient redundancy (defense in depth), then one control system may be used. Consideration for fuel and core design (e.g. what is the core excess reactivity, the temperature feedback coefficients and margins to key component temperatures), as well as the novelty of the system(s) for protection and control; and the level of redundancy or diversity of the systems will be considered. Reactivity control systems will be subject to IEEE-379-2014, or an equivalent standard.