



VALAR ATOMICS

Ward250

Nuclear Safety Design Agreement

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EXECUTIVE SUMMARY

This Nuclear Safety Design Agreement (NSDA) establishes the regulatory framework and safety basis development approach for Ward250, a ≤ 250 kWth High Temperature Gas-cooled Reactor (HTGR) research facility at the Utah San Rafael Energy Research Center (USREL). The facility represents a critical step in advancing HTGR technology through a systematic demonstration program that leverages non-nuclear testing completed under the WardZero program.

Ward250 will operate as a Contractor-Owned, Contractor-Operated (COCO) facility under DOE jurisdiction, following established precedents such as the Vallecitos Nuclear Center. The facility design directly utilizes hardware components that have undergone full-scale testing at design conditions, significantly reducing traditional construction and startup risks. This extensive pre-qualification supports an accelerated regulatory pathway while maintaining comprehensive safety assurance.

The safety analysis approach adapts the NRC Research Test Reactor framework from NUREG-1537, which has guided licensing of over 30 university research reactors for decades. This proven methodology, combined with DOE-STD-1271-2025 requirements, provides a robust yet appropriately scaled regulatory framework for Ward250's limited hazard profile. The Maximum Hypothetical Accident methodology from NUREG-1537 demonstrates acceptable consequences without requiring probabilistic risk assessments unsuitable for a 12-month research mission.

The Agreement defines a two-step licensing approach under 10 CFR 830, progressing through a Preliminary Documented Safety Analysis (PDSA) early in the design process, followed by a final Documented Safety Analysis (DSA) for the as-built facility. This approach aligns with DOE-STD-1271-2025 requirements while incorporating graded approaches appropriate for the facility's low hazard profile and limited 12-month operational mission.

The inherent safety characteristics of the HTGR design provide multiple layers of protection against radioactive release. TRISO fuel particles demonstrate retention capabilities exceeding 99.99% under normal operating conditions and maintain integrity up to 1600°C during postulated accidents. Passive decay heat removal systems ensure core cooling without reliance on active systems or external power. These defense-in-depth features, combined with the low power level and limited operational period, result in projected public doses well below regulatory limits even under Maximum Hypothetical Accident conditions.

Ward250 will operate exclusively under DOE authorization for its entire lifecycle. No transition to NRC licensing is planned or intended, as the facility's research mission and limited operational period are optimally served through DOE oversight.

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ABBREVIATIONS

This list contains the abbreviations used in this document.

Abbreviation or Acronym	Definition
ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CDS	Component Design Specification
CFR	Code of Federal Regulations (USA)
DOE	Department of Energy (USA)
DSA	Deterministic Safety Analysis
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
FAT	Factory Acceptance Test
HTGR	High Temperature Gas-Cooled Reactor
HTR	High Temperature Reactor
HTTR	High Temperature Test Reactor
HVAC	Heating, Ventilation and Air Conditioning
I&C	Instrumentation and Control
ICD	Interface Control Document
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers, Inc.
kWth	Kilowatt thermal
LLW	Low-level Waste
MHTGR	Modular High Temperature Gas Cooled Reactor
NHSS	Nuclear Heat Supply System
PBS	Plant Breakdown Structure
PDS	Plant Design Specification
PGA	Peak Ground Acceleration
PRA	Probabilistic Risk Assessment
QA	Quality Assurance
RCCS	Reactor Cavity Cooling System
SDD	System Design Description
SSC	Structures, Systems and Components
TBC	To Be Confirmed

Abbreviation or Acronym	Definition
TBD	To Be Determined
TRISO	TRI Structural ISOtropic
UPS	Uninterruptible Power Supply
V&V	Verification and Validation

1. PROJECT PURPOSE AND DESIGN

1.1. HIGH LEVEL FUNCTIONAL AND PERFORMANCE OBJECTIVES

Ward250 serves as a research and demonstration facility designed to advance High Temperature Gas-cooled Reactor technology through integrated systems testing and operational data generation. The facility's objectives encompass both technical demonstration and regulatory precedent establishment for future HTGR deployments.

Primary functional objectives include:

- Demonstrate integrated HTGR systems performance under prototypical conditions
- Validate computational methods through benchmark-quality experimental data
- Establish operational procedures and training programs for HTGR technology
- Demonstrate functional containment through TRISO fuel performance validation,
- Confirm passive safety system performance under various operational scenarios
- Generate licensing precedents applicable to commercial HTGR deployment

Performance objectives establish quantitative targets for facility operation:

- Achieve steady-state operation at power levels up to 250 kWth
- Demonstrate core outlet temperatures of 750°C under normal operations
- Maintain fuel temperatures below 1250°C during anticipated operational occurrences
- Complete defined test matrices within the 12-month operational period
- Achieve availability factors exceeding 80% during test campaigns
- Generate data quality meeting international benchmark standards

The functional containment demonstration validates the HTGR safety philosophy where the fuel itself serves as the primary barrier to fission product release, eliminating reliance on conventional pressure-retaining containment structures.

The facility design emphasizes simplicity and inherent safety while maintaining flexibility for research operations. Modular construction enables efficient assembly and future decommissioning. Passive safety systems minimize reliance on active components and operator actions. Conservative thermal margins accommodate research transients without challenging safety limits. Comprehensive instrumentation provides detailed characterization of system behavior under various conditions.

1.2. LIFECYCLE CONCEPT OF OPERATIONS

Ward250 follows a structured lifecycle spanning approximately 18 months from authorization through decommissioning, with each phase building upon previous accomplishments to ensure safe and efficient execution. This compressed timeline

leverages the extensive preparation completed under the WardZero program while maintaining appropriate regulatory oversight and safety assurance.

The pre-operational phase, extending from NSDA approval through startup authorization, encompasses final design completion, regulatory reviews, and facility preparation. Design activities focus on nuclear-specific modifications to the proven WardZero configuration, including neutron detection systems, nuclear instrumentation, and radiation monitoring equipment. Regulatory interactions with DOE follow the structured approach defined in this Agreement, with defined milestones and review periods ensuring predictable progress. Facility modifications, limited primarily to nuclear-specific installations, proceed in parallel with licensing activities to maintain schedule efficiency.

The operational phase comprises 12 months of nuclear operations divided into distinct testing campaigns. Initial criticality and low-power physics testing validate nuclear design predictions and establish operational parameters. Power ascension proceeds through defined hold points with comprehensive testing at each level. Steady-state operations at various power levels generate performance data and demonstrate reliability. Transient testing within approved limits provides validation of safety analyses and predictive methods. Throughout operations, comprehensive data collection supports both immediate research objectives and long-term technology development.

The post-operational phase ensures proper facility closure and knowledge preservation. Defueling operations transfer spent fuel to appropriate storage, leveraging procedures developed during initial loading. Facility decommissioning returns the site to unrestricted use, simplified by the modular construction approach and limited contamination. Knowledge management activities preserve operational experience and research results for future applications. Lessons learned documentation captures both technical insights and regulatory precedents, informing subsequent HTGR deployment.

2. SAFETY ANALYSIS REQUIREMENTS

2.1. GRADED APPROACH BASIS

Ward250 implements a graded approach to safety requirements commensurate with its risk profile, which is comparable to NRC-licensed university research reactors. Key factors supporting this graded approach include:

- Low operating power level (≤ 250 kWth power level)
- Limited radioactive material inventory
- Short operational duration (12 months)
- Absence of commercial production pressure
- Inherent safety characteristics (negative temperature coefficient, passive decay heat removal)
- Robust fuel form (TRISO particles with demonstrated retention $>99.99\%$)
- Remote site location (400m to site boundary, 800m to nearest residence, 1200m to nearest group)

This risk profile, similar to facilities like the MIT Research Reactor and Missouri S&T Reactor, justifies streamlined requirements while maintaining robust safety assurance.

2.2. SAFETY ANALYSIS METHODOLOGY

Ward250 implements the Maximum Hypothetical Accident (MHA) methodology from NUREG-1537, adapted for DOE authorization requirements. Valar Atomics responded to DOE FOA DE-FOA-0003569 proposing this approach, which was accepted by virtue of Ward250's selection for the DOE Reactor Pilot Program. This approach, successfully employed at numerous research reactors, provides a conservative bounding analysis that demonstrates acceptable consequences without requiring detailed probabilistic assessments inappropriate for a limited-duration research facility.

The MHA methodology postulates a hypothetical fission product release that bounds all credible accidents, regardless of probability or specific initiating events. This release assumes failure of multiple barriers beyond expected performance, including TRISO fuel particle failures exceeding demonstrated limits, breach of the primary pressure boundary without consideration of design margins, and adverse meteorological conditions that maximize dose consequences. The analysis demonstrates that even under these extremely conservative assumptions, radiological consequences remain acceptable.

Source term development for the MHA considers the maximum inventory of fission products that could be present during operations. The analysis assumes continuous operation at maximum licensed power for sufficient time to reach equilibrium fission product inventories. Release fractions conservatively bound experimental data from TRISO fuel testing, with additional margins applied to account for uncertainties. Noble

gases and volatile fission products receive particular attention due to their potential for release and radiological significance. The resulting source term substantially exceeds any realistic release scenario.

Atmospheric dispersion modeling employs Gaussian plume methodology with conservative parameters that maximize ground-level concentrations. The analysis assumes F-stability conditions with low wind speeds that maximize plume concentration at receptor locations. No credit is taken for plume rise, building wake effects, or deposition. Receptor locations include the site boundary at 400 meters, representing the nearest point of public access, the nearest actual residence at approximately 800 meters, and co-located worker locations at 100 meters from the reactor building. Dose calculations follow Federal Guidance Report methodologies, incorporating both external and internal exposure pathways.

Preliminary results indicate site boundary doses below 0.5 rem Total Effective Dose Equivalent, well below the 25 rem evaluation guideline for Safety Class SSC designation. Doses at the nearest residence remain below 0.1 rem TEDE, demonstrating minimal impact to actual public receptors. Co-located worker doses below 5 rem TEDE confirm Safety Significant classification adequacy for worker protection systems. These results demonstrate substantial margin to regulatory limits even under MHA bounding assumptions.

The favorable MHA results support several key project decisions. The absence of Safety Class SSC simplifies design, procurement, and quality assurance requirements while maintaining adequate safety. Hazard Category 2 designation based on material at risk rather than consequence supports appropriate but not excessive regulatory requirements. Emergency planning requirements remain limited to on-site response, avoiding the complexity of off-site evacuation planning. The graded approach to safety management programs reflects the limited hazard potential while maintaining essential controls.

Adaptation for DOE authorization includes explicit consideration of worker protection consistent with 10 CFR 830 requirements, incorporation of defense-in-depth concepts per DOE expectations, and interface with DOE safety management programs. The MHA methodology bounds consequences regardless of initiating event probability, providing robust safety assurance without excessive analytical burden.

TRISO fuel performance assumptions presented in this NSDA are based on AGR-specification TRISO fuel, including fuel failure fractions, temperature limits, and fission product retention characteristics derived from AGR fuel qualification program data. These preliminary assumptions will be validated in the PDSA through detailed analysis of Ward250-specific operating conditions and fuel specifications. If Ward250 fuel specifications differ from AGR-specification TRISO, the affected performance parameters and safety analysis assumptions will be updated in the PDSA accordingly.

2.3. HAZARD IDENTIFICATION AND EVALUATION

The hazard identification process for Ward250 systematically evaluates potential challenges to safety functions through a structured methodology that considers facility-specific features, operational activities, and external influences. This comprehensive approach ensures all credible hazards receive appropriate consideration in the safety analysis.

Internal hazards arise from facility operations and equipment failures:

- Reactivity insertion events - Limited by inherent characteristics and administrative controls on excess reactivity (<0.50), with detailed evaluation confirming adequate shutdown margin
- Loss of coolant flow - Examines partial and complete flow interruption, crediting natural circulation capabilities demonstrated during WardZero testing
- Heat removal challenges - Various cooling system failure modes analyzed, with passive heat removal paths providing defense-in-depth
- Fuel handling accidents - Limited to initial core loading and final defueling, with specific procedures and controls developed

External hazards evaluation considers site-specific environment and regional characteristics:

- Seismic hazards - Site-specific geotechnical data establishes design basis earthquake parameters with structural analyses confirming adequate margins
- Extreme weather - High winds, temperature extremes, and precipitation evaluated based on 100-year return period data
- External fire - Wildland and industrial fire sources screened based on 10-mile separation distance and natural barriers
- Aircraft impact - Negligible risk due to remote location, no nearby airports, and absence of designated flight paths over the site

The evaluation process for each identified hazard considers both frequency and consequence to support graded analysis approaches. High-frequency events with minimal consequences may receive simplified treatment, while low-frequency, high-consequence events undergo detailed analysis to confirm adequate protection. This risk-informed approach focuses analytical resources on scenarios most important to safety while maintaining comprehensive hazard coverage.

2.4. SAFETY CLASSIFICATION METHODOLOGY

Safety classification follows a functional approach linking SSC importance to the four fundamental safety functions. Classification criteria include:

- Safety Class (SC): SSC whose failure could result in off-site doses exceeding 25 rem TEDE
- Safety Significant (SS): SSC preventing worker doses >5 rem or providing significant defense-in-depth
- Defense-in-Depth (DID): SSC enhancing safety margins without credited safety functions

Based on MHA analysis showing site boundary doses <0.5 rem, no Safety Class SSC are required. Safety Significant designations apply to systems directly supporting fundamental safety functions.

2.5. FUNDAMENTAL SAFETY FUNCTIONS

Ward250 implements the four fundamental safety functions mandated by DOE-STD-1271-2025 through a combination of inherent characteristics, passive systems, and engineered controls. These functions work synergistically to ensure adequate protection of workers, the public, and the environment under all operational states and postulated accident conditions.

Table 1: Safety Functions

Fundamental Safety Function	Implementation Method	Contributing SSC
Radioactive Material Confinement	Multiple barriers: TRISO coatings, primary pressure boundary, reactor building	TRISO fuel, Reactor vessel, Building and Building ventilation
Reactivity Control	Inherent negative feedback, control rods, burnable poisons	Negative coefficient reactivity. Control Rod Drive System, Reactor Protection System
Decay Heat Removal	Passive natural circulation, vessel auxiliary cooling	Structures, HVAC , Ultimate heat sink to atmosphere
Preservation of Adequate Radiation Shielding	Gamma and neutron shielding to maintain radiation to acceptable levels in occupied areas	Reactor vessel shielding that cannot be inadvertently defeated

Radioactive material confinement relies on multiple independent barriers to prevent release of fission products. The TRISO fuel particles provide the primary containment through multiple ceramic coating layers that retain fission products under normal and accident conditions. The helium primary system provides a secondary barrier, with the reactor building structure providing final confinement. This defense-in-depth approach ensures that multiple failures would be required before any significant release could occur.

Reactivity control maintains the reactor in a safe configuration through a combination of inherent characteristics and engineered systems. The reactor's inherent negative temperature coefficient provides immediate negative feedback to any power excursion, limiting the magnitude of reactivity transients without operator action. Administrative controls on excess reactivity, verified through physics measurements, ensure adequate shutdown margin is maintained throughout the operational cycle. Independent and diverse shutdown mechanisms provide defense-in-depth against common-mode failures.

Decay heat removal ensures fuel integrity through multiple heat removal paths that function without reliance on external power or operator action. The Reactor Cavity Cooling System removes heat through natural circulation of air or water, with capacity validated through WardZero testing. The Vessel Auxiliary Cooling System provides an independent heat removal path, ensuring redundancy in this critical safety function. Direct conduction and radiation to surrounding structures provides an ultimate heat sink that cannot be disabled. The large thermal mass of the graphite core and reflector moderates temperature transients, providing time for heat removal systems to establish equilibrium conditions.

Radiation shielding preservation maintains dose rates within acceptable limits for workers and the public during normal operations and accident conditions. The biological shield surrounding the reactor vessel attenuates neutron and gamma radiation to acceptable levels in occupied areas. Reactor vessel materials and configuration provide inherent shielding that cannot be inadvertently defeated. Building structures provide additional shielding for external areas, with thickness and materials selected based on conservative source terms. Administrative controls ensure temporary shielding remains in place during operations requiring access to normally restricted areas.

3. SAFETY DOCUMENT FORMAT AND CONTENT

3.1. DOCUMENTED SAFETY ANALYSIS APPROACH

Ward250 will implement a Documented Safety Analysis (DSA) development process consistent with DOE-STD-1271-2025. This approach, necessitated by the compressed schedule, proposes submittal of the final DSA at 90% design completion followed by verification of as-built configuration.

The Preliminary Documented Safety Analysis (PDSA) will be submitted early in the design process when safety functions are clearly defined and preliminary analyses demonstrate design adequacy. Given the as-built nature of WardZero hardware, the PDSA can be developed with high confidence in system configurations and performance parameters. The PDSA provides DOE with visibility into design decisions affecting safety and establishes the performance requirements governing subsequent procurement and construction activities.

Feedback received from DOE during the PDSA review will be tracked, evaluated, and incorporated directly into the final DSA. This ensures comprehensive resolution of all DOE comments while maintaining schedule efficiency.

3.2. PDSA STRUCTURE AND CONTENT

The PDSA generally follows the format and content for research reactor operations consistent with NUREG-1537 guidance. This structure provides comprehensive coverage of safety-related topics while maintaining focus on elements most relevant to the facility's limited hazard profile.

The PDSA incorporates lessons learned from WardZero testing, providing technical insights for design decisions and operational approaches. The PDSA provides a comprehensive, preliminary assessment of the safety aspects of the facility and demonstrates that the facility can be operated safely.

Table 2 shows a crosswalk from the format NUREG-1537 content provisions to the PDSA content guidance described in DOE-STD-1271-2025.

3.3. FINAL DSA STRUCTURE AND CONTENT

The final Documented Safety Analysis will be submitted at 90% design completion, representing the definitive safety basis for Ward250 operations while acknowledging specific elements subject to final configuration. Building upon the PDSA foundation, the DSA provides comprehensive documentation of the facility design and safety characteristics, with clear identification of items pending final as-built verification.

Updates from the PDSA include incorporation of as-built drawings and specifications reflecting actual construction, validated accident analyses, finalized operating procedures and resolution of all PDSA review comments with appropriate technical basis.

The final DSA serves as the authorization basis for nuclear operations, with DOE approval confirming that the facility provides adequate protection of workers, the public, and the environment. Following approval, the DSA becomes a living document, maintained current through the Unreviewed Safety Question process to reflect facility modifications and operational experience.

Technical Safety Requirements derived from the DSA establish the operational envelope within which the facility must be operated. These requirements, implemented through procedures and training, ensure that the assumptions and controls credited in accident analyses remain valid throughout the operational period.

Safety Management Programs described in the DSA provide the institutional framework supporting safe operations. Each program description will reference implementing procedures and demonstrate compliance with applicable requirements.

Table 2 shows a crosswalk from the format NUREG-1537 content provisions to the PDSA/DSA guidance described in DOE-STD-1271-2025. Additionally, Valar atomics will evaluate compliance with the requirements of DOE-STD-1237-2021, address any departures and consider other voluntary consensus standards such as ANS-15.21.

Table 2: NUREG-1537 content provisions to the PDSA/DSA guidance

NUREG-1537 Based Chapter (Ward250 PDSA/DSA Chapter)	PDSA Inclusion (Included/Excluded)	DOE-STD-1271-2025 Compliance PDSA Element Addressed	Final DSA Considerations
Chapter 1: The Facility	Included (preliminary)	Element 1: Facility Description and Reference to Preliminary Design Documentation	Updated to reflect 90% design completion
Chapter 2: Site Characteristics	Included (preliminary)	Supports Element 2: Hazard and Accident Analyses (external hazards)	Updated to reflect 90% design completion
Chapter 3: Design of Structures, Systems, and Components	Included (preliminary)	Element 3: Safety Structures, Systems, and Components	Updated to reflect 90% design completion
Chapter 4: Reactor Description	Included (preliminary)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 5: Reactor Coolant Systems	Included (preliminary)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 6: Engineered Safety Features	Included (preliminary)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 7: Instrumentation and Control Systems	Included (preliminary)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 8: Electrical Power Systems	Included (preliminary)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 9: Auxiliary Systems	Included (if safety-related)	Element 1: Facility Description Element 3: Safety SSC	Updated to reflect 90% design completion
Chapter 10: Experimental Facilities	Excluded	Not Applicable to Ward250 Project	Not Applicable to Ward250 Project
Chapter 11: Radiation Protection and Waste Management	Included (partial)	Element 5: Approach for Safety Management Programs	Safety management programs finalized – submitted separately

NUREG-1537 Based Chapter (Ward250 PDSA/DSA Chapter)	PDSA Inclusion (Included/Excluded)	DOE-STD-1271-2025 Compliance PDSA Element Addressed	Final DSA Considerations
Chapter 12: Conduct of Operations	Included (partial)	Element 5: Approach for Safety Management Programs	Safety management programs finalized – submitted separately
Chapter 13: Accident Analysis	Included	Element 2: Hazard/Accident Analyses Element 4: Analyses Methodologies	Updated to reflect 90% design completion
Chapter 14: Technical Specifications	Excluded	Not Required at PDSA	Required to support DSA Addressed in separate TSR submittal
Chapter 15: Financial Qualifications	Excluded	Not required for application	Not required for application
Chapter 16: Other License Considerations	Excluded	Not Applicable to Ward250 Project	Not Applicable to Ward250 Project
Chapter 17: Decommissioning	Excluded	Not required for PDSA	Approach included in DSA
Chapter 18: Highly Enriched to Low-Enriched Uranium Conversion	Excluded	Not Applicable to Ward250 Project	Not Applicable to Ward250 Project
Appendices	Excluded	Not Applicable to Ward250 Project	Not Applicable to Ward250 Project

4. REGULATORY ENGAGEMENT PROCESS

4.1. WARD250 ENGAGEMENT PLAN

Given the expedited 12-month schedule from authorization to operation, Valar Atomics proposes a streamlined engagement strategy with the DOE Review Team focused on critical authorization milestones.

Planned Submittal Packages:

- Nuclear Safety Design Agreement (NSDA) – 9/22/2025
- Preliminary Documented Safety Analysis (PDSA) – 11/01/2025
- Final Documented Safety Analysis (DSA) – 01/06/2026
- Technical Safety Requirements (TSRs) – 01/06/2026
- Safety Management Program Documentation – finalized programs submitted to support DSA
- Startup and Commissioning Plan – submitted in to support DSA
- Requests for Equivalencies/Exemptions – submitted in to support DSA¹

Structured Communication:

- Periodic progress teleconferences with DOE Project Manager
- Action item tracking
- PDSA Review Support- RFI and design audit support
- DSA Review Support - RFI and design audit support
- Readiness Assessment Planning - Coordinate DOE Readiness Assessment (RA) scope and schedule
- As-Built Verification - Confirm final configuration prior to fuel load through verification
- Startup Authorization - Support DOE startup approval process

This focused engagement approach respects the compressed schedule while ensuring DOE maintains appropriate oversight throughout the authorization process.

Note 1: Equivalency and exemption requests should be identified and justified during PDSA submittal and must receive DOE approval prior to DSA submittal.

4.2. STATE AND LOCAL COORDINATION

While Ward250 operates under DOE regulatory authority, coordination with state and local stakeholders ensures comprehensive emergency preparedness, environmental compliance, and community acceptance. This coordination recognizes the legitimate

interests of regional authorities while maintaining clear regulatory boundaries. Valar Atomics anticipates interfacing with multiple state and local agencies:

- Utah Department of Environmental Quality (DEQ)
- Utah Division of Waste Management and Radiation Control (DWMRC)
- Emery County Emergency Management
- Emery County Fire Department
- Local Emergency Response Organizations

The State of Utah maintains agreements with DOE regarding notification and coordination for nuclear facilities within the state. Ward250 will comply with applicable provisions including environmental monitoring data sharing, emergency response coordination protocols, and periodic facility status updates. State representatives may observe but not direct DOE regulatory activities, maintaining appropriate separation of authorities while promoting transparency.

Valar Atomics maintains primary responsibility for environmental compliance under DOE oversight, with coordination through the Idaho Operations Office for federal-state interface requirements. Environmental permits and regulatory coordination are managed through Valar's Environmental, Safety, and Health (ES&H) organization, with DOE maintaining approval authority for activities affecting the safety basis or authorization conditions.

NEPA compliance follows DOE P 451.1B with environmental review coordination through DOE Idaho Operations Office per 10 CFR 1021. Radiological air emissions will be evaluated for compliance with 40 CFR 61 Subpart H (National Emission Standards for Hazardous Air Pollutants). Coordination with EPA regarding NESHAPs applicability and notification requirements will be conducted through DOE Idaho Operations Office consistent with federal facility provisions in 40 CFR 61.

Local emergency response coordination includes:

- Familiarization tours for emergency responders to understand facility layout and hazards
- Table-top exercises testing communication protocols and response procedures
- Provision of facility hazard information supporting emergency planning
- Establishment of direct communication links for event notification
- Annual coordination meetings to maintain response readiness

Environmental compliance incorporates both DOE requirements and applicable state regulations. Air emissions and water discharges comply with state permits where applicable, with monitoring data provided to demonstrate compliance. Waste management follows both DOE orders and state regulations for non-radioactive materials. Environmental assessments address both radiological and non-radiological impacts,

providing comprehensive evaluation of facility effects. Regular environmental reporting maintains transparency with state environmental agencies.

5. KEY SAFETY DECISIONS FOR THE DESIGN

5.1. SSC TARGET PERFORMANCE

The Safety Significant SSC designations presented in this section represent preliminary determinations based on initial MHA calculations. Final SSC safety classification will be submitted for DOE approval with the PDSA, supported by completed MHA consequence analysis demonstrating doses remain below Safety Class thresholds per DOE-STD-1027-2025.

Reactor Protection System

- Scram insertion time: <2 seconds from trip signal
- Single failure criterion satisfied
- Availability: >99% during operations

Decay Heat Removal Systems

- HVAC / RCCS capacity: 100% decay heat at all times
- Natural circulation established within 30 minutes
- No operator action required for 72 hours

TRISO Fuel Performance

- Maximum normal operating temperature: 650°C
- Failure fraction: <1E-4 at 1600°C
- Fission product retention: >99.99%

5.2. SAFETY SYSTEM RESPONSES

Normal Operations:

- Automatic power reduction for high temperature
- Control rod run-in for anomalous flux patterns
- RCCS modulation for temperature control

Off-Normal Operations:

- Reactor scram on high power/period
- Passive heat removal activation
- Confinement isolation on radiation detection

5.3. MONITORING REQUIREMENTS

Continuous Monitoring:

- Neutron flux (3 independent channels)
- Core outlet temperature
- Primary coolant pressure
- Area radiation levels

Periodic Surveillance:

- Control rod drop times (monthly)
- RCCS flow verification (weekly)
- Fuel temperature instrumentation (daily)

5.4. SAFETY LIMITS

Reactor Core:

- Maximum continuous power: 100 kWth
- Maximum short duration power (1hr): 250 kWth
- Peak fuel temperature: 1250°C
- Minimum shutdown margin: 2.0% $\Delta k/k$ (Without uncertainty analysis)

Primary System:

- Maximum pressure: 3.0 MPa
- Maximum outlet temperature: 650°C

5.5. OPERATING LIMITS

Maximum Fission Product Inventory

- Fuel burnup limit: 30 megawatt-days

5.6. MINIMUM STAFFING REQUIREMENTS

Operating Crew:

- Senior Reactor Operator: 1 per shift
- Reactor Operator: 1 per shift
- Radiation Protection Technician: On-call

Support Staff:

- Facility Director (SRO qualified)
- Technical Support Engineer
- Maintenance Technician

5.7. USE OF QUALIFIED FUEL

Ward250 will use TRISO-coated particles meeting the following qualification basis:

- AGR-1/2 irradiation test data

- German AVR/THTR operational experience
- Safety testing to 1800°C demonstrating integrity
- Manufacturing under NQA-1 quality program

Updates to fuel design affecting assumptions and analysis will be updated in the PDSA.

Per DOE-STD-1271-2025 Attachment 2, the facility will implement real-time fission break monitoring with reactor shutdown required on high primary coolant activity. The monitoring system design and operational thresholds will be established in the PDSA based fuel performance data and qualified operating envelope.

5.8. PHYSICAL SECURITY AND SAFEGUARDS

Ward250 implements security and safeguards measures consistent with DOE requirements for special nuclear material protection. Detailed security measures are addressed in separate controlled documents including the Physical Security Plan and Material Control and Accountability Plan. The facility design incorporates defense-in-depth security features appropriate for the material at risk and threat assessment.

6. SAFETY SSC CLASSIFICATION RULES AND TERMINOLOGY

6.1. CLASSIFICATION CATEGORIES

Safety Class (SC)

- Definition: SSC whose failure could result in off-site radiological consequences exceeding 25 rem TEDE
- Ward250 Application: No SSC meet this threshold based on MHA analysis

Safety Significant (SS)

- Definition: SSC performing functions to prevent or mitigate:
 - Worker doses exceeding 5 rem TEDE
 - Significant defense-in-depth functions
 - Significant environmental releases
- Ward250 Application: RPS, RCCS, Control Rod System

Defense-in-Depth (DID)

- Definition: SSC providing margin beyond minimum safety requirements
- Ward250 Application: secondary instrumentation, building ventilation

6.2. WARD240 HIERARCHY OF CONTROLS APPLICATION

Priority Order (per DOE-STD-1271-2025):

1. Elimination/Substitution
2. Engineering Controls
 - 2.1. Inherent/Passive: TRISO fuel, negative temperature coefficient
 - 2.2. Active: Control rod insertion, RPS actuation
3. Administrative: Operating procedures, surveillance requirements, safety management programs
4. PPE: Minimal reliance for normal operations

6.3. DEFENSE-IN-DEPTH IMPLEMENTATION

Level 1 - Prevention:

- Conservative design margins
- Quality assurance in fabrication
- Operational limits and conditions

Level 2 - Control:

- Automatic protective actions
- Inherent feedback mechanisms
- Operator response procedures

Level 3 - Mitigation:

- Passive heat removal
- Multiple fission product barriers
- Emergency response capabilities

6.4. FUNCTIONAL CLASSIFICATION

Functions:

- Reactivity Control (F1)
- Heat Removal (F2)
- Confinement (F3)
- Supporting Functions (F4)

Table 3: SSC Allocation Matrix

SSC	F1	F2	F3	F4	Classification
TRISO Fuel	X	-	X	-	SS
Control Rods	X	-	-	-	SS
RCCS	-	X	-	-	SS
RPS	-	-	-	X	SS
Radiation Shielding	-	-	-	X	SS

6.5. PERFORMANCE CATEGORY ASSIGNMENT

Ward250 SSC are assigned to DOE Natural Phenomena Design Categories based on their safety significance:

NDC-2 SSC:

- Reactor Protection System
- Control Rod Drive System
- Reactor Cavity Cooling System
- Primary structural components

NDC-1 SSC:

- Secondary instrumentation
- General building structures
- Radiation Shielding
- Support systems

7. AUTHORITY TO CONFIRM AND MAKE SAFETY DECISIONS

Valar Atomics serves as the Design Authority for Ward250, with the Chief Operating Officer/Chief Nuclear Officer (COO/CNO) holding ultimate contractor responsibility for design safety decisions

7.1. DESIGN DECISION FRAMEWORK

Design Authority Structure:

- COO/CNO: Overall design integrity and safety decision authority
- Engineering Lead: Technical design decisions and design control implementation
- USQ Lead: Coordinates the implementation of the USQ process
- Quality Assurance Lead: Independent oversight of design changes and USQ determinations

7.2. DECISION PROCESS

- 1) Identification: Engineering Lead identifies design issues requiring safety evaluation
- 2) Analysis: Technical evaluation performed by qualified engineering personnel
- 3) Verification: Independent verification by Qualified personnel not involved in original design
- 4) USQ Determination: USQ Lead coordinates 10 CFR 830.203 Unreviewed Safety Question evaluation
- 5) Approval: COO/CNO approves design changes affecting safety basis
- 6) Quality Assurance Lead: Independent oversight of design and USQ processes
- 7) Documentation: Design decisions documented in configuration management system

7.3. INTERFACE WITH DOE SBAA

Design changes are evaluated through the USQ process to determine if prior DOE approval is required. Changes requiring DOE approval include:

- Modifications to safety basis assumptions
- Changes affecting TSR limits or conditions
- Alterations to safety SSC functional requirements
- Deviations from approved codes and standards

Design decisions within the approved authorization basis are made by Valar Atomics' Design Authority, with DOE retaining ultimate safety basis approval authority.

The Joint Test Group approach outlined in DOE-STD-1271-2025 Section 9.2 will be implemented as a TSR for post-startup testing activities. This approach ensures appropriate DOE oversight of test program execution while maintaining operational flexibility within approved safety limits.

8. DOSE CONSEQUENCE ANALYSIS

The Maximum Hypothetical Accident (MHA) analysis demonstrates that the Ward250 reactor maintains public and worker doses well below regulatory limits even under extreme accident conditions with conservative assumptions. The analysis shows:

- Public dose at site boundary (400m): <1 mSv (100 mrem)¹
- Worker dose at 100m: <50 mSv (5 rem)
- Control room dose: <5 mSv (500 mrem)

These results support the facility's Hazard Category 2 designation and demonstrate the inherent safety of the TRISO fuel design.

8.1. MHA DEFINITION AND SCENARIO

8.1.1. Initiating Event

The MHA is initiated by a postulated large break in the reactor vessel structure, resulting in:

- Instantaneous and complete depressurization of the primary system
- Loss of forced helium cooling
- Direct pathway for radioactive material release to the environment

8.1.2. Conservative Assumptions

The analysis employs highly conservative assumptions to bound all credible accident scenarios:

Fuel Performance:

- TRISO failure rate: 2× AGR-1/2 test program values (conservative multiplier)
- Failed TRISO particles: 100% release of noble gases and halogens
- Intact TRISO particles: Attenuated release through coating layers
- No credit for fuel kernel retention of solid fission products

Barrier Performance:

- No credit for helium pressure boundary retention
- No credit for building confinement or HVAC filtration
- No credit for helium purification system

¹ 1 Sievert (Sv) = 100 rem / 1 millisievert (mSv) = 100 millirem (mrem)

- No credit for reactor cavity cooling system (RCCS)
- No credit for any active mitigation systems

Release Conditions:

- Ground-level release at 1.5m elevation
- No holdup or decay time (instantaneous release)
- 100% of circulating activity released

Meteorological Conditions:

- Stability Class F (moderately stable atmosphere)
- Wind speed: 1 m/s
- Most conservative dispersion conditions

8.2. SOURCE TERM ANALYSIS**8.2.1. Core Inventory Calculation**

Based on OpenMC neutronic analysis with 3 MWd total burnup:

- Total radioactive inventory calculated using Rigorous 2-Step (R2S) methodology
- Neutron transport → reaction rates → depletion calculation → decay source terms
- Conservative 30 EFPD operation assumed for inventory buildup

8.2.2. Key Radionuclides Released

The following isotopes contribute to the dose consequences:

Noble Gases (100% release from failed TRISO):

- Kr-87, Kr-88
- Xe-131m, Xe-135m, Xe-138

Halogens (100% release from failed TRISO):

- I-131 (primary dose contributor)

Volatile Fission Products (attenuated release):

- Cs-137, Cs-134
- Sr-90
- Te-132

Other Fission Products:

- Ba-140, La-140
- Ce-144, Pr-144

- Ru-106, Rh-106
- Zr-95, Nb-95
- Mo-99

Actinides (minimal release due to low volatility):

- Trace amounts of Pu, Am, Cm isotopes

8.2.3. Release Fractions

- Failed TRISO: 100% of gaseous and volatile inventory
- Intact TRISO: Release attenuated by SiC and PyC layers
- Circulating activity: 100% assumed released
- Plated-out activity: Conservative fraction assumed mobilized

8.3. ATMOSPHERIC DISPERSION ANALYSIS

8.3.1. Dispersion Model

- Gaussian plume model per regulatory guidance
- Class F stability (most conservative)
- Ground-level release assumption
- No building wake or plume rise credit

8.3.2. Dispersion Parameters

- Site boundary (400m): $\chi/Q \approx 2.5 \times 10^{-4} \text{ s/m}^3$
- Worker location (100m): $\chi/Q \approx 4.0 \times 10^{-3} \text{ s/m}^3$
- Control room: Indoor/outdoor air exchange considered

8.4. DOSE CALCULATION RESULTS

8.4.1. Dose Pathways Considered

1. External exposure from passing plume
2. Inhalation during plume passage
3. Ground deposition (external)
4. Resuspension (minimal contribution)

8.4.2. Calculated Doses

Public Dose at Site Boundary (400 m):

- Total Effective Dose Equivalent (TEDE): <1 mSv (100 mrem)
- Primary contributors: I-131 (thyroid), noble gases (external)
- Well below 10 CFR 100 limit of 250 mSv (25 rem)

Worker Dose at 100 m:

- TEDE: <50 mSv (5 rem)
- Meets 10 CFR 835 annual occupational limit
- Assumes no evacuation or protective actions

Control Room Dose:

- TEDE: <5 mSv (500 mrem) with normal ventilation
- Meets operator protection requirements
- No credit for emergency ventilation isolation

8.5. COMPARISON TO REGULATORY LIMITS

Table 4: Comparison of MHA analysis to Regulatory limits

Receptor	Calculated Dose	Regulatory Limit	Margin Factor
Public (400m)	<1 mSv (100 mrem)	250 mSv (25 rem) (10 CFR 100)	>250×
Public (400m)	<1 mSv (100 mrem)	10 mSv (1 rem) (USNRC NPUF)	>10×
Worker (100m)	<50 mSv (5 rem)	50 mSv/yr (5 rem/yr) (10 CFR 835)	Meets limit
Control Room	<5 mSv (500 mrem)	50 mSv (5 rem) (10 CFR 835)	>10×

8.6. SOFTWARE QUALITY ASSURANCE

Computer codes used for Ward250 design and safety evaluation will be qualified in accordance with the Ward250 Quality Assurance Program Description (Document 100474). The QAPD implements Software Quality Assurance requirements per NE O 414.1, including provisional use of modern HTGR computational codes where safety margins accommodate code uncertainties.

8.7. CONCLUSIONS

The MHA analysis demonstrates:

1. Robust Safety Margins: Even with highly conservative assumptions and no credit for engineered safety features beyond the fuel, doses remain well below regulatory limits.
2. TRISO Performance: The coated particle fuel provides the primary barrier to fission product release, validating the fuel-centered safety approach.
3. Graded Approach Justification: Low unmitigated consequences support:

- Hazard Category 2 classification
 - No requirement for Safety Class SSCs
 - Simplified emergency planning zone
 - Research reactor regulatory framework
4. Site Suitability: The 400m site boundary provides adequate protection with substantial margin.

9. NATURAL PHENOMENA HAZARD (NPH) DESIGN CATEGORIZATION

9.1. NATURAL PHENOMENA DESIGN CATEGORY (NDC) DETERMINATION

Natural phenomena hazard design categorization for Ward250 follows DOE-STD-1020 methodology, establishing Natural Phenomena Design Categories (NDC) based on unmitigated radiological dose consequences from SSC failure during NPH events. This bounding dose calculation approach ensures SSC are designed to withstand natural phenomena events commensurate with their safety significance and potential radiological consequences.

The NDC determination process performs bounding dose calculations for each safety-significant SSC, evaluating unmitigated radiological consequences if the SSC fails during a natural phenomena event. NDC-2 designation applies to SSC whose failure could result in: (1) public doses exceeding 5 rem TEDE, (2) co-located worker doses exceeding 25 rem TEDE, or (3) loss of critical defense-in-depth functions. NDC-1 designation applies to SSC with dose consequences below these thresholds but still contributing to facility safety. Based on preliminary bounding dose calculations, the unmitigated consequences remain below 5 rem to the maximally exposed offsite individual, supporting the NDC categorizations. Non-safety SSC follow applicable building codes without additional NPH requirements.

Design criteria for each NDC level establish target performance goals and associated natural phenomena loads. NDC-2 structures must meet a performance goal of 5×10^{-4} annual probability of failure, requiring design for natural phenomena events with approximate return periods of 2,500 years. NDC-1 structures meet a 10^{-3} annual probability of failure goal, corresponding to approximate return periods of 500 years. These performance goals ensure appropriate protection while avoiding excessive conservatism for a limited-life facility.

The Ward250 design implements these categorizations through specific design requirements for affected SSC. Safety Significant SSC including the Reactor Protection System, Reactor Cavity Cooling System, and Control Rod Drive System are designed to NDC-2 criteria. Defense-in-Depth SSC receive NDC-1 designation where their failure could complicate accident response or recovery. The reactor building structure requires evaluation for both categories, with critical areas housing safety-significant equipment designed to NDC-2 while general areas meet NDC-1 requirements.

9.2. SITE-SPECIFIC NPH PARAMETERS

The following NPH parameters are preliminary, based on regional data and generic site conditions. Final parameters will be established following site-specific geotechnical investigations and probabilistic hazard analyses.

9.2.1. Table: Preliminary NPH Design Parameters

Table 5: NPH Design Parameters

Parameter	NDC-2 Value	NDC-1 Value	Basis
Peak Ground Acceleration	0.2g	0.1g	USGS 2,500-yr return
Design Wind Speed (3-sec gust)	130 mph	90 mph	ASCE 7-16 Risk Cat III
Tornado Wind Speed	200 mph	N/A	DOE-STD-1020 Region II
Snow Load	30 psf	30 psf	Local building code
Design Temperature Range	-20°F to 115°F	Same	100-year extremes
Note: Parameters subject to refinement based on site-specific studies			

Preliminary seismic parameters based on regional seismicity and generic site conditions indicate a design basis earthquake with peak ground acceleration of 0.2g for NDC-2 SSC. This value encompasses contributions from regional fault systems and background seismicity, with appropriate consideration of epistemic and aleatory uncertainties. Site response analyses will refine these values based on site-specific soil properties and structure-specific requirements. NDC-1 SSC utilize a peak ground acceleration of 0.1g, consistent with the reduced performance goals for these components.

Wind and tornado hazards reflect regional meteorological patterns and topographical influences. The NDC-2 design basis wind speed of 130 mph (3-second gust at 33 feet) bounds historical extreme wind events with appropriate return period. Tornado parameters for NDC-2 design include maximum wind speed of 200 mph with associated pressure drop and missile spectra. NDC-1 structures utilize reduced wind speeds consistent with building code requirements for the region. The relatively low tornado frequency in Utah supports these parameters as appropriately conservative.

Flood hazards receive limited consideration due to site elevation and distance from significant water bodies. The site location on a mesa approximately 100 feet above the surrounding terrain precludes flooding from local precipitation or regional water sources. Probable Maximum Precipitation evaluations confirm adequate site drainage without challenging safety-related structures. As such, flooding does not represent a credible NPH challenge for Ward250, simplifying design requirements and emergency planning.

External hazards beyond traditional NPH events receive appropriate consideration based on site-specific conditions. Lightning protection follows NFPA 780 standards with appropriate grounding systems for safety-related structures. Snow loads comply with regional building codes with appropriate factors for roof configuration. Temperature extremes bound by regional historical data inform HVAC system design and structural

evaluations. Volcanic hazards, while present in the broader region, screen out based on distance and low probability during the operational period.

9.3. DESIGN CRITERIA APPLICATION

Natural phenomena design criteria implementation follows a graded approach consistent with the facility's limited operational period and low hazard profile. Structural design employs appropriate load combinations and resistance factors ensuring adequate margins for all credible NPH events. Dynamic analyses account for soil-structure interaction where significant, with appropriate damping values based on material properties and stress levels. Non-linear behavior receives consideration where it provides benefit, with appropriate limitations to ensure ductile response.

Equipment qualification demonstrates the capability of safety-significant components to perform their functions during and after NPH events following industrial good practice.

System interactions receive explicit evaluation to prevent NPH-induced failures from propagating beyond individual components. Spatial interactions consider the potential for falling objects or displaced equipment to damage safety-significant SSC. Functional interactions evaluate the effects of NPH-induced failures of non-safety systems on safety functions. Common-cause vulnerabilities receive particular attention to ensure diversity and redundancy are not compromised. Physical separation and barriers provide protection where necessary to prevent adverse interactions.

9.4. STRUCTURAL DESIGN APPROACH

The structural design approach for Ward250 implements defense-in-depth principles while maintaining appropriate focus on truly safety-significant elements. This balanced approach provides robust protection for critical safety functions while avoiding excessive conservatism in areas with minimal safety impact.

The reactor citadel consists of prefabricated, post-tensioned concrete modules that provide radiation shielding and protection from external events. The reactor vessel is supported by an independent self-supporting steel frame structure within the citadel, preventing load transfer while maintaining precise alignment. This design approach enables efficient construction while providing robust protection.

The reactor building surrounding the citadel provides weather protection and secondary confinement while facilitating operational access. Steel frame construction with metal siding offers adequate protection for NDC-1 requirements while maintaining construction efficiency. Localized reinforcement protects specific safety-significant components where required. Structural failure modes analysis in the PDSA will confirm that building failures do not prevent safety systems from performing safety functions. The building configuration facilitates natural circulation cooling paths that remain functional following NPH events. Access routes for emergency response receive appropriate protection to ensure availability when needed.

Support structures are categorized based on safety function:

Safety Class Structures: None required based on MHA results

Safety Significant Structures:

- RCCS intake/exhaust structures - Designed to NDC-2 criteria ensuring passive heat removal capability
- Electrical equipment buildings - Houses Class 1E power supplies with NDC-2 protection
- Control room - Enhanced protection (NDC-2) for event response though not required for safety

Defense-in-Depth Structures:

- General reactor building - NDC-1 criteria for weather protection and secondary confinement
- Maintenance facilities - Standard building codes with separation from safety SSC

Construction quality assurance ensures structural designs are properly implemented. Concrete placement follows appropriate inspection and testing standards. Structural steel fabrication and erection comply with AISC specifications for nuclear facilities. Welding procedures and welder qualifications meet applicable requirements. Non-destructive examination verifies critical connections meet design specifications. These quality measures provide confidence that as-built structures will perform as designed under NPH challenges.

10. CODE OF RECORD REQUIREMENTS

Ward250 implements a risk-informed approach to code and standard application, utilizing established requirements appropriate for the facility's hazard profile while incorporating justified alternatives where standard requirements provide no safety benefit. This approach follows established Research Test Reactor precedent where industrial codes and standards provide the primary design basis, with nuclear-specific requirements applied only where necessary for radiological safety. This practice, successfully demonstrated at facilities like MURR and MIT Reactor, avoids unnecessary conservatism while maintaining robust safety margins. The following requirements apply to Ward250:

10.1. FEDERAL REGULATIONS (10 CFR SERIES)

Requirement	Title	Applicability	Exceptions/Alternatives
10 CFR 830	Nuclear Safety Management	Full	None
10 CFR 835	Occupational Radiation Protection	Full	None
10 CFR 851	Worker Safety and Health Program	N/A	Replaced by OSHA standards (29 CFR 1910/1926) per COCO model

10.2. DOE ORDERS - NUCLEAR SAFETY & OPERATIONS

Requirement	Title	Applicability	Exceptions/Alternatives
NE O 151.1	Comprehensive Emergency Management System	Tailored	On-site emergency response only (no off-site planning required)
NE O 225.1	Accident Investigations	Full	None anticipated
NE O 226.1	Implementation of Department of Energy Oversight Policy	Full	None
NE P 226.1	Policy for Federal Oversight and Contractor Assurance Systems	Full	None
NE O 227.1	Independent Oversight Program	Full	None
NE O 231.1B	Environment, Safety and Health Reporting	Full	None
NE O 232.1	Occurrence Reporting and Processing of Operations Information	Full	None
NE O 414.1	Quality Assurance	Tailored	ANS-15.8 QA program for research reactors

Requirement	Title	Applicability	Exceptions/Alternatives
NE O 420.1	Facility Safety	Tailored	See Alternative Requirements (Appendix C)
NE O 422.1	Conduct of Operations	Tailored	ANS-15.4 for operator qualification
NE O 425.1	Verification of Readiness to Startup or Restart Nuclear Facilities	Full	None
NE O 426.2	Personnel Selection, Training, Qualification, and Certification Requirements	Tailored	ANS-15.4 operator qualification program
NE O 433.1	Maintenance Management Program for DOE Nuclear Facilities	Tailored	Limited 12-month operational period
NE O 435.1	Radioactive Waste Management	Full	None
NE O 458.1	Radiation Protection of the Public and the Environment	Full	None
NE O 470.1	Office of Nuclear Energy Security Program	Full	None

10.3. DOE ORDERS - ADMINISTRATIVE & SECURITY

Requirement	Title	Applicability	Exceptions/Alternatives
DOE M 441.1-1	Nuclear Material Packaging	Full	None
DOE O 442.1B	Department of Energy Employee Concerns Program	Full	No alternative requirements allowed per OTA
DOE O 442.2	Differing Professional Opinions for Technical Issues	Full	No alternative standard allowed per OTA
DOE P 451.1B	National Environmental Policy Act Compliance Program	Full	None
DOE O 460.1D Chg 1	Hazardous Materials Packaging and Transportation Safety	Full	None
DOE O 460.2B	Departmental Materials Transportation Management	Full	None
DOE O 461.1C Chg 1	Packaging and Transportation for Offsite Shipment of Materials of National Security Interest	Full	None
DOE O 461.2	Onsite Packaging and Transfer of Materials of National Security Interest	Full	None

Requirement	Title	Applicability	Exceptions/Alternatives
DOE O 471.1B	Identification and Protection of Unclassified Controlled Nuclear Information	Full	None
DOE O 471.6 Chg 4	Information Security	Full	None
DOE O 471.7	Controlled Unclassified Information	Full	None
DOE O 475.1	Counterintelligence Program	Full	None
DOE O 475.2B	Identifying Classified Information	Full	None
DOE O 486.1A	Foreign Government Sponsored or Affiliated Activities	Full	None

10.4. DOE STANDARDS

Requirement	Title	Applicability	Exceptions/Alternatives
NE-STD-1020-2025	Natural Phenomena Hazard Analysis and Design Criteria for DOE Facilities	Full	None
NE-STD-1027-2025	Hazard Categorization of DOE Nuclear Facilities	Full	None
DOE-STD-1073-2016	Configuration Management	Full	None
DOE-STD-1104-2016	Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents	Tailored	Federal staff use only; may be tailored per authorization process
DOE-STD-1237-2021	Documented Safety Analysis for DOE Reactor Facilities	Tailored	Using DOE-STD-1271-2025 pathway
DOE-STD-1271-2025	Authorization Pathway for Nuclear Facilities	Tailored	Primary authorization standard for Ward250
DOE-STD-1628-2013	Development of Probabilistic Risk Assessments for Nuclear Safety Applications	Tailored	Graded approach for research reactor
DOE-STD-3009-2014	Preparation of Nonreactor Nuclear Facility Documented Safety Analysis	Tailored	Modified per DOE-STD-1271-2025; chemical hazards without nuclear nexus excluded
DOE-STD-3009-2025	DSA Preparation	Tailored	See Alternative Requirements

10.5. OTHER REQUIREMENTS

Requirement	Title	Applicability	Exceptions/Alternatives
10 CFR 851	Worker Safety and Health Program	Phased ¹	29 CFR 1910/1926 (OSHA) per COCO authorization model. ¹

Note 1: DOE Idaho Operations Office exemption request in process for construction activities pending 10 CFR 851 revision to align with Administrative Procedures Act and OSHA requirements.

10.6. KEY CODE APPLICATIONS

ASME Boiler and Pressure Vessel Code

The reactor vessel and primary pressure boundary components follow ASME BPVC Section VIII for pressure vessels, with appropriate consideration of the facility's limited operational period and moderate operating conditions. Time-dependent degradation mechanisms require minimal consideration given Ward250's 12-month operational life. Creep damage accumulation at maximum operating temperature (750°C) remains below 0.1% of allowable limits. Fatigue cycles from startup/shutdown and operational transients total less than 100, compared to design allowances exceeding 10,000 cycles. These factors justify simplified analysis approaches and extended inspection intervals.

ANSI/ANS Standards for Research Reactors

The ANSI/ANS-15 series provides the primary operational framework for Ward250, leveraging decades of successful research reactor experience. ANS-15.1 establishes the format and content for safety analysis, adapted through the DOE authorization process described herein. ANS-15.4 guides operator selection, training, and qualification with appropriate scaling for facility complexity. ANS-15.8 quality assurance requirements provide a graded framework implementing 10 CFR 830 Subpart A requirements while avoiding excessive documentation for non-safety systems. This standard extends the 18 criteria of 10 CFR 830.122 through research reactor-specific guidance, ensuring appropriate quality measures without the extensive procedural burden of NQA-1. ANS-15.11 radiation protection programs scale to actual hazards rather than imposing commercial plant requirements. ANS-15.16 emergency planning requirements align with the limited off-site consequences demonstrated through accident analysis.

IEEE Standards for Electrical and I&C Systems

Electrical and I&C systems implement applicable IEEE standards based on actual safety functions rather than blanket Class 1E designation. Given Ward250's passive safety approach, most electrical systems serve monitoring rather than actuation functions, justifying commercial-grade components with augmented quality requirements where appropriate.

The Ward250 code of record has been provided to the DOE concurrent with this submittal ([100437] Ward250 Plant Codes and Standards (Code of Record)).

10.7. ALTERNATIVE REQUIREMENTS SUMMARY TABLE

Requirement	Standard Approach	Ward250 Alternative	Justification
Quality Assurance	NQA-1	ANS-15.8	Research reactor precedent
Operator Licensing	DOE O 422.1	ANS-15.4	RTR standard practice
Emergency Planning	DOE O 151.1D full	Limited on-site only	Low source term
Worker Safety	10 CFR 851	OSHA (29 CFR 1910/1926)	COCO model
DSA Submittal	As-built configuration	90% design completion	Existing design maturity enables early submittal
Fire protection and passive safety system requirements	DOE Order 420.1C	Tailored application for research reactor	Technical justification in Appendix C.3.6

Details for each alternative are provided in Appendix C.

10.8. VERIFICATION OF EQUIVALENCY

Alternative requirements verification considers a graded approach while employing comparative analysis, regulatory precedent from similar facilities, and/or independent review ensuring objective assessment. This verification provides assurance that alternatives maintain safety objectives while reducing unnecessary burden.

Regulatory precedent includes historic U.S. HTGR (Peach Bottom, Fort St. Vrain) and currently operating international facilities (HTR-10 in China, HTTR in Japan) that demonstrate safe operation with similar design features. These facilities validate key safety assumptions including TRISO fuel performance, passive heat removal effectiveness, and inherent reactivity feedback characteristics.

11. ENGINEERING PROCESS AND REQUIREMENTS FLOW DOWN

Ward250 implements a formal requirements management process ensuring complete traceability from regulatory requirements through design implementation to operational procedures. This systematic approach maintains configuration control while accommodating the expedited project schedule.

The requirements hierarchy flows from regulatory requirements (10 CFR 830, DOE Orders) and NSDA commitments through the Plant Design Specification establishing top-level technical requirements. System Design Descriptions allocate requirements to specific systems, with Component Specifications detailing implementation. Interface Control Documents define boundaries and interactions, while Procedures and Instructions implement operational controls.

Verification and validation employ multiple methods including analysis, demonstration, inspection, and test. The Requirements Verification Matrix tracks completion of all verification activities, with acceptance criteria clearly defined. Configuration management ensures changes are evaluated for impact on safety and regulatory commitments, with appropriate DOE notification for significant modifications.

12. APPENDICES

12.1. APPENDIX A: PLANT DESIGN DESCRIPTION

12.1.1. Key Design Parameters Table

Table 6: Ward250 Key design parameters

Parameter	Value	Basis
Thermal Power	100 kWth (Continuous) ≤250 kWth (Limited tests)	License limit
Fuel Type	TRISO-coated UCO	AGR qualification
Coolant	Helium	Inert, single phase
Reactor Intlet temperature	250°C nominal	
Core Outlet Temperature	650°C nominal	Material limits
System Pressure	3.0 MPa	Low pressure design
Core Height	1.8 m	Neutronics optimization
Core Diameter	1.5 m	Thermal design
Number of Fuel Elements	76	Core configuration
Fuel Enrichment	4.95% U-235	LEU limits
Maximum Fuel Temperature	1250°C	Qualification limit (Normal Operation)
Shutdown Margin	>2.0% $\Delta k/k$	Desing Target (compensate for uncertainty)
Core HM Mass	250 kg	Criticality calculation
Reflector Material	Graphite	Neutron economy

12.2. APPENDIX B: SCHEDULE AND MILESTONES

12.2.1. Project Schedule and Milestones

Table 7: Project Milestones

Milestone	Target Date	Duration	Status
NSDA Submittal	09/22/2025	45 day review	In Review
PDSA Submittal	11/01/2025	45 day review	Planned
DSA Submittal	01/06/2026	45 day review	Planned
Construction Complete	04/13/2026	-	Planned
Readiness Review	Phased ¹	N/A	Planned
Initial Criticality	06/30/2026	-	Planned

Note 1: Readiness activities are anticipated to occur at key milestones prior to and after completion of construction.

12.3. APPENDIX C: TECHNICAL JUSTIFICATIONS FOR ALTERNATIVE REQUIREMENTS

12.3.1. C.1 Quality Assurance Alternative

Standard Requirement: NQA-1

Ward250 Alternative: ANSI/ANS-15.8-1995

Justification:

ANS-15.8 provides a complete quality assurance framework specifically developed for research reactors, with decades of successful implementation at DOE and NRC facilities. The standard addresses all 18 criteria of 10 CFR 830.122 while providing appropriate grading for research reactor applications. Given Ward250's limited operational period and low hazard profile, the streamlined documentation and procedural requirements of ANS-15.8 provide adequate assurance of quality while avoiding unnecessary burden.

12.3.2. C.2 Operator Licensing

Standard Requirement: DOE Fundamentals Engineering Review

Ward250 Alternative: ANSI/ANS-15.4 operator qualification

Justification:

ANS-15.4 provides comprehensive guidance for research reactor operator selection, training, and qualification. This approach has been successfully implemented at numerous university research reactors with excellent safety records. The standard's focus on facility-specific training aligns well with Ward250's unique design features and limited operational mission.

12.3.3. C.3 Emergency Planning

Standard Requirement: Full implementation of DOE O 151.1D

Ward250 Alternative: On-site emergency response only

Justification:

MHA analysis demonstrates site boundary doses <0.5 rem TEDE, well below Protective Action Guidelines. The remote site location (800m to nearest residence) provides natural isolation. Limited source term and short operational period support simplified emergency planning focused on worker protection and coordination with local responders.

12.3.4. C.4 Worker Safety

Standard Requirement: 10 CFR 851

Ward250 Alternative: OSHA standards (29 CFR 1910/1926)

Justification:

The COCO operational model and limited radiological hazards support use of standard OSHA requirements during the construction phase. This approach, approved through the OTA, provides appropriate worker protection without redundant regulatory burden. Integration with the radiation protection program ensures comprehensive worker safety.

12.3.5. C.5 DSA Submittal Timing

Standard Requirement: Submit final DSA for as-built facility configuration per DOE-STD-3009-2025

Ward250 Alternative: Submit final DSA at 90% design completion

Justification:

The WardZero program has completed design, installation and testing of major safety-significant systems, providing as-built data for these dual-use SSC. The limited number of safety significant SSC remaining allows for efficient verification of as-built configuration during readiness review activities and prior to reactor startup.

Verification Approach:

- Prior to reactor startup, Valar Atomics will complete:
- Field configuration walkdowns of any remaining SSC
- As-built drawing verification package
- USQ screening of any deviations from DSA descriptions
- As-built design documentation for DOE readiness review

Regulatory Compliance:

This alternative maintains full compliance with 10 CFR 830.204 requirements while enabling timely DSA submittal. The approach is authorized under DOE-STD-1271-2025 Section 2.1.d.3, which permits SBAA-approved alternatives that maintain safety objectives.

Schedule Benefit:

Enables DOE review concurrent with final design completion, making project schedule objective practically achievable while maintaining all safety requirements and configuration control.

12.3.6. C.6 DOE Order 420.1C Facility Safety

Standard Requirement: Full implementation of DOE O 420.1C facility safety requirements

Ward250 Alternative: Tailored implementation for research reactor application per Code of Record (100437)

Justification:

Ward250 implements tailored approaches to DOE O 420.1C requirements based on research reactor precedent and the facility's low hazard profile. Detailed alternative requirements, technical justifications, and applicable standards are documented in the Ward250 Plant Codes and Standards (Code of Record), Document 100437.

Key areas include:

Reactor Core Assembly: ANS-15.1 and ANS-15.8 research reactor standards applied in lieu of commercial facility requirements. TRISO fuel functional containment and passive decay heat removal reduce reliance on engineered safety features.

Reactor Protection System: IEEE-603 and IEEE-7-4.3.2 digital safety system standards with SIL ratings applied, consistent with research reactor practice and appropriate for the facility's low power and inherent safety characteristics.

Fire Protection: NFPA standards suite applied for industrial facilities with research reactor considerations per NFPA 801, recognizing predominant use of non-combustible materials (graphite, helium, steel, concrete) in safety-significant areas.

These tailored approaches maintain DOE O 420.1C safety objectives while applying graded requirements appropriate for research reactor operations.