Standard Review Plan

Lines of Inquiry for Design and Engineering Review of DOE Nuclear Facilities

September 2018

Acknowledgments

This Standard Review Plan (SRP) on *Lines of Inquiry for Design and Engineering Review of DOE Nuclear Facilities* is prepared by the Department of Energy, Office of Environmental Management (EM), Office of Chief of Nuclear Safety (CNS).

The SRP is intended to provide a performance-based and transparent approach to the DOE Federal and prime contractor monitoring of nuclear projects. It's designed to focus management attention on areas that impact project delivery and avert unwarranted changes to the code of record which often result in costly and time-consuming retrofits.

Toward that end, the EM/CNS have prepared other complementary SRPs for the review of nuclear facilities/projects in the areas of design and engineering, nuclear and facility safety, project management, worker safety, environment, security, and quality assurance. The publication of these SRPs was made possible through the concerted efforts and cooperation from the management and staff of EM headquarters, DOE field offices, and contractor organizations.

Technical support and subject matter expertise in support of the SRPs was provided by Link Technologies, Inc., under contract DE-NA0001224, DE-BP0004765 (http://www.linksolutions.com).

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Abbreviations and Acronyms

AC	Administrative Control
AEGL	Acute Exposure Guideline Level
ALARA	As Low As Reasonably Achievable
AHS	All-Hazards Survey
ANS	American Nuclear Society
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ANSI	American National Standards Institute
BEP	Best Engineering Practice
BIO	Basis for Interim Operations
CA	Composite Analysis
CAS	Criticality Alarm System
CD	Critical Decision
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGD	Commercial Grade Dedication
CM	Configuration Management
CNS	Chief of Nuclear Safety
CFHA	Comprehensive Flood Hazard Assessment
COR	Code of Record
CPR	Construction Project Review
CRD	Contractor Requirements Document
CSDR	Conceptual Safety Design Report
CSE	Criticality Safety Evaluation (Criticality Safety); *also:* Cognizant System Engineer (Systems Engineering)
CSP	Criticality Safety Program
CSR	Criticality Safety Representative
CTA	Central Technical Authority
DA	Design Authority
DBA	Design Basis Accident
DBFL	Design Basis Flood Level
DBPL	Design Basis Precipitation Level
DBT	Design Basis Threat

DCS	Distributed Control System
DID	Defense-In-Depth
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DRT	Design Review Team
DSA	Documented Safety Analysis
D&D	Deactivation, Decontamination and Decommissioning
EAL	Emergency Action Level
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act
EM	Office of Environmental Management
EMCP	Emergency Management Core Program
EMHMP	Emergency Management Hazardous Material Program
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency
EPHA	Emergency Planning Hazards Assessment
EPZ	Emergency Planning Zone
ERAP	Emergency Readiness Assurance Plan
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety and Health
FDC	Flood Design Category
FHA	Fire Hazard Analysis
HFE	Human Factors Engineering
HPSB	High Performance and Sustainable Building
FDC	Flood Design Category
FPD	Federal Project Director
FPE	Fire Protection Engineer
FSA	Flood Screening Analysis
FTF	Filter Test Facility
FW	Facility Worker
HA	Hazard Analysis
HVAC	Heating, Ventilation, and Air Conditioning
HAZWOPER	Hazardous Waste Operations and Emergency Response Program
HC	Hazard Category
HEPA	High Efficiency Particulate Air
HFE	Human Factor Engineering
HLW	High Level Waste
HPSB	High Performance and Sustainable Building

HMSP	Hazardous Material Screening Process
HVAC	Heating, Ventilation, and Air Conditioning
IAEA	International Atomic Energy Agency
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IPR	Integrated Project Review
IPT	Integrated Project Team
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
JIC	Joint Communication Center
LEED	Leadership in Energy and Environmental Design
LOI	Line of Inquiry
LLW	Low Level Waste
MAR	Material At Risk
MPFL	Maximum Possible Fire Loss
MSDS	Material Safety Data Sheets
NCS	Nuclear Criticality Safety
NDC	NPH Design Category
NEHRP	National Earthquake Hazard Reduction Program
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NICET	National Institute for Certification in Engineering Technologies
NPH	Natural Phenomena Hazard
NQA	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission
NMMP	Nuclear Maintenance Management Program
OSHA	Occupational Safety and Health Administration
PA	Performance Assessment
PC	Performance Category (Seismic)
PDSA	Preliminary Documented Safety Analysis
PFHA	Probabilistic Flood Hazard Assessment
PPHA	Probabilistic Precipitation Hazard Assessment
PSDR	Preliminary Safety Design Report
PSHA	Probabilistic Seismic Hazard Analysis
PSO	Program Secretarial Office
PWHA	Probabilistic Wind Hazard Assessment
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act

RFP	Request for Proposals
RGD	Radiation Generating Device
RPP	Radiation Protection Program
SAAB	Safety Basis Approval Authority
SAC	Specific Administrative Control
SC	Safety Class
SDC	Seismic Design Category
SDS	Safety Design Strategy
SEP	System Engineer Program
SIC	Safety-In-Design
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SO	Secretarial Officer
SRP	Standard Review Plan
SS	Safety Significant
SSC	Structures, Systems and Components
TDP	Technology Development Plan
TEDE	Total Effective Dose Equivalent
TEEL	Temporary Emergency Exposure Limit
TL	Threat Level
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TRU	Transuranic Waste
TMP	Technology Maturation Plan
UL	Underwriters Laboratories
USDA	U.S. Department of Agriculture
USQ	Unreviewed Safety Question
VHA	Volcanic Hazard Assessment
WAC	Waste Acceptance Criteria
WDC	Wind Design Category
WIR	Wastes Incidental to Reprocessing

Overview

This Standard Review Plan (SRP), *Lines of Inquiry for Design and Engineering Review of DOE Nuclear Facilities*, was developed by the Office of Field Operations Oversight/Chief of Nuclear Safety (CNS), under the Office of the Environmental Management (EM). The SRP is designed to help strengthen the technical rigor of line management oversight and federal monitoring of the design process of DOE nuclear facilities.

This SRP (hereafter refers to as the *Design and Engineering SRP)* provides consistent performance-based review guidance and Lines of Inquiry (LOIs) to assure that engineering and technical requirements are appropriately applied for the design of DOE nuclear facilities.

The organization of this document is as follows:

- Section 1.0 presents a roadmap to
    - Technical disciplines for a typical Design Review Team (DRT) (listed in Table 1).
    - Design Review Topics (listed in Table 2).
    - LOIs relevant to each discipline
- Section 2 provides the performance expectations for design review at each phase of the design lifecycle. The design phase can be classified as (1) conceptual design (usually 0 to ~30 percent design completion); (2) preliminary design (~30 to ~60 percent completion); or (3) final design (90 to 100 percent completion). See Appendix B for a graphical illustration of how the design process continuum is related to the DOE project management Critical Decision process and the nuclear facility safety basis development process.
- Section 3 presents guidance on conducting the design review. It provides the general principles for forming, managing, and performing the DRT.
- Appendix A provides a set of LOIs for each engineering and technical discipline of the DRT, which can be external review teams and internal project review teams of the DOE or the contractors. If necessary, the DRTs may modify or supplement these LOIs based on project-specific situations.

  The DRT should determine which LOIs are appropriate for the different phases in the design process (conceptual, preliminary, and final) or at different percentage of design completion: 10, 30, 60, 90, and 100 percent.

- Appendix B illustrates the relationship among the design, DOE Critical Decision and safety basis development processes.

A list of abbreviations and acronyms can be found on page v.

Additionally, there are other SRPs developed by the CNS which provide supplemental LOIs for use during the design review process. These SRPs include

1. Safety Basis Program Review During Design, Volume 2, February 2015
2. Safety Basis Program Review of TSRs, USQs and SERs, Volume 5, February 2015
3. Code of Record, May 2014
4. Safety Design Strategy, November 2014
5. Conceptual Design Review, March 2010
6. Preliminary Design Review, March 2010
7. Final Design Review, March 2010
8. Conceptual Safety Design, March 2010
9. Preliminary Safety Design, March 2010
10. Seismic Design Expectations, March 2010
11. Quality Assurance for Critical Decision Reviews, March 2010
12. Protocol on QAP/QIP Review, March 2010
13. Commercial Grade Dedication (CGD), August 2013
14. Construction Readiness Review, March 2010
15. Checkout, Testing, and Commissioning Plan, March 2010
16. Preparation for Facility Operations, August 2013
17. Readiness Review, March 2010

Please contact the appropriate subject matter expert (SME) within the Office of Field Operations/Chief of Nuclear Safety (CNS), EM-3.11, with any questions or request for technical assistance. Staff profile and contact information, as well as electronic copy of all SRPs can be found on CNS website: http://energy.gov/em/chief-nuclear-safety

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1 Design and Engineering Lines of Inquiry

The Lines of Inquiry (LOIs) are divided into 24 engineering and technical topics, which were identified from the review of DOE regulations, directives, and technical standards. The LOIs also capture the best engineering practices (BEP) of DOE and commercial design review activities.

The LOIs are for use by the 13 typical engineering review disciplines (Table 1) of a typical Design Review Team (DRT). In addition, all teams have to address the common considerations of Configuration Management and Quality Assurance.

Table 1. Typical Design Review Team disciplines.

1. Process/Systems	6. Mechanical	11. Operation
2. Geotechnical/Site Characterization	7. Electrical	12. Inspection and Maintenance
3. Plant Layout	8. Instrumentation and Controls	13. Security and Emergency Response
4. Civil Structural	9. Environmental, Safety and Health	Common: Configuration Management and Quality Assurance
5. Materials and Corrosion	10. Construction	

Table 2 lists the LOI topics and Table 3 provides a crosswalk on how the sets of LOIs can be used by the engineering review disciplines.

Table 2. Engineering and technical topics [1] Lines of Inquiry (LOIs).

1. Nuclear	9. Radiation Protection	17. Technology Readiness
2. Siting Criteria	10. Hazardous Materials (include Chemicals)	18. Waste Management
3. Natural Phenomena Hazards (includes Structural Engineering)	11. Sustainability	19. D&D Considerations During Design
4. Fire Protection	12. Human Factors	20. Systems Engineering
5. Criticality	13. Safeguards and Security	21. Configuration Management
6. Mechanical	14. Pressure Safety	22. Nuclear Maintenance Management Program
7. Electrical	15. Environmental Protection	23. Plant Layout
8. Instrumentation and Control	16. Emergency Preparation	24. Materials and Corrosion

[1] These topics were identified from the review of DOE regulations, directives, and technical standards. The references are identified in the LOIs tables in Appendix A.

Table 3. Crosswalk of LOI sets by engineering review discipline.

Discipline	SRP Section	LOI Set
1 Process/Systems	Technology Readiness	17
	Systems Engineering	20
	Nuclear	2
	Criticality	5
	Hazardous Materials	10
	Environmental Protection	15
2 Geotechnical/Site Characterization	Siting Criteria	1
	NPH	3
	Environmental Protection	15
3 Plant Layout	Plant Layout	23
	Radiation Protection	9
	Hazardous Materials	10
	Sustainability	11
	Waste Management	18
	D&D Considerations During Design	19
4 Civil – Structural	NPH	3
	D&D Considerations During Design	19
5 Materials and Corrosion	Materials and Corrosion	24
6a Mechanical – Equipment	Mechanical	6
	Pressure Safety	14
6b Mechanical – Fire Protection	Fire protection	4
	Mechanical	6
6c Mechanical – Ventilation – Confinement	Nuclear	2
	Mechanical	6
	Waste Management	18
7 Electrical	Electrical	7
8 Instrumentation and Controls	Instrumentation and Controls	8
	Criticality	5
9 Environment, Safety and Health (ES&H)	Nuclear	2
		See SRPs on Safety Basis Program Review.
	Criticality	5
	Hazardous Materials	10
	Radiation Protection	9
	Human Factor	12
	Environmental Protection	15
	Emergency Preparedness	16

Discipline	SRP Section	LOI Set
10 Construction	See the separate Construction Readiness Review SRP.	See the Construction Readiness Review SRP.
11 Operations	Human Factor	12
	Radiation Protection	9
	Emergency Preparation	16
	Waste Management	18
12 Inspections and Maintenance	Nuclear Maintenance Management	22
	Human Factor	12
13 Security and Emergency Response	Safeguards and Security	13
	Emergency Preparation	16
All Disciplines	Configuration Management	21
	Systems Engineering	20
	See separate SRPs on Quality Assurance (QA) and Commercial Grade Dedication (CGD).	See SRPs on QA and CGD.

2 Design Progress Expectations

The general expectations for design review are listed in Table 4. The expectations are listed for all disciplines and for the individual disciplines for the conceptual, preliminary, and final design phases. See Appendix B on how the % design is related to the design phases, and how the design continuum is related to the Critical Decision continuum and safety basis continuum.

In June 2015, the Secretary of Energy had established a revised project management policies and principles for DOE capital asset projects. [2] These policies and principles were integrated into the revision of DOE O 413.3B and DOE-STD-1189. The secretarial memoranda specifies that nuclear projects (Hazard Category 1, 2, and 3) shall achieve at least 90% design completion expectations prior to Critical Decision-2 (CD-2). these 90% design completion expectations are included in Table 4, under All Disciplines, and for final design.

Table 4. Design Progress Expectations by Discipline

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
1 Process and Systems	Conceptual Design	• Basic chemical and nuclear process systems: The process technology in the form of chemistries, nuclear criticality, process reactions, thermo-hydraulics of mixing or separation, feedstock (incoming materials), output (products), phase change, reaction physics, et al. should be completed and verified, either by exact replication of a successful process (same processes, same sizes, same environments) or by testing. • Support systems and utilities: The design of support systems and utilities (cooling water, instrument air, steam supply, heat exchangers, et al.) need not be completed at this stage. • Alternative studies must have been completed so that there is no risk of change in technology in favor of a more efficient process. • The thermo-hydraulic designs (flows, equipment sizing) should be completed for the basic systems. • Safety classification, and defense-in-depth and single-failure design should be completed for the Basic chemical and nuclear systems, and for the containment-confinement system.
	Preliminary Design	• The design of support systems and utilities should be completed. • The P&IDs should be completed for all systems. • The line lists (pressures, temperatures, cycles) should be completed for all systems. • Safety classification, and defense-in-depth and single-failure design should be completed for all systems.

[2] Secretary of Energy Memorandum, *Project Management Policies and Principles,* June 8, 2015.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
		• All products and chemicals should be identified for safe hazard protection. • Thermo-hydraulic design of utilities should be well underway.
	Final Design	• At the 90 percent design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (for example, reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
2 Geotechnical / Site Characterization	Conceptual Design	• Land use of the facility, public exclusion zone, emergency response, et al. should have been approved. • Local geology, meteorology, and hydrology studies should be completed satisfactorily. • The design-basis magnitude of natural phenomena hazards should have been established and finalized. • Seismicity should be completed in the form of hazards analysis and ground motions. • Human-induced hazards should have been identified. • Environmental-impact studies and permits should be completed.
	Preliminary Design	• No activity; issues should all have been resolved at end of Conceptual Design.
	Final Design	• No activity; issues should all have been resolved at end of Conceptual Design.
3 Plant Layout	Conceptual Design	• Layout plot plans of buildings and major structures should be completed, with verification that processes can be accommodated, including future expansions. • The 3D facility layout should have been reviewed and approved by all disciplines. • Civil–structural drawings of buildings and large structures should be completed and ready for design analysis and qualification.
	Preliminary Design	• The 3D layout of distribution systems (piping, ducts, cable trays, et al.) and components (fans, compressors, et al.) should be completed. All interferences should have been resolved.
	Final Design	• Layout reflects final specifications and design of systems and components.
4 Civil – Structural	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the Code of Record (COR). • The design basis loads (normal, natural phenomena hazards, et al.) and safety and seismic classifications should have been defined. • The buildings models should have been started.
	Preliminary Design	• The structural design analyses should be near completion. • The in-structure seismic response spectra should be final for the design of SSCs.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
5 Materials and Corrosion	Conceptual Design	• The corrosion mechanisms should have been defined for each system and subsystem. • Materials options for the base processes should have been selected. • Material tests should have been planned for alloys and non-metallic for corrosive environments.
	Preliminary Design	• Materials (base metal and weldments) tests should have been completed and materials selected and incorporated into project specifications. • Design lives and risk-informed inspections and replacement strategies should have been developed.
	Final Design	• Material selections and inspection-repair strategies should be final.
6a Mechanical – Equipment	Conceptual Design	• The codes, standards and design criteria for mechanical distribution systems (piping, tubing) and equipment (static: vessels, tanks; and active: pumps, valves, compressors) should be completed and entered into the COR. • The design loads and environments should be in development. • The location of major mechanical equipment (reactors, process rooms, et al.) should be completed and provided to layout.
	Preliminary Design	• The design loads and environments should be in development. • The design of 60% of the mechanical equipment should be completed, including 90% of the Basic chemical and nuclear equipment, in accordance with their safety classification. • The pressure safety strategy should be completed.
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
6b Mechanical – Fire Protection	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the COR. • Site selection should have accounted for fire and emergency response capabilities onsite and offsite. • Internal and external fire sources should be completed. • The fire protection strategy (fire water source, fire loop, wet or dry system, standpipe, building distribution system, active and passive protection, fire walls and fire doors, et al.) should be completed.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
		• The multilayer strategy for safety-related fire protection should be completed, including defense in depth and single failure. • The controls for the interface with the ventilation system should be completed. • The location of major fire-protection equipment (water tanks, water main loop, et al.) should be completed and provided to layout.
	Preliminary Design	• The layout and hydraulic sizing should be completed. • Fire safety and emergency response coordination should be completed. • The design of 60% of the mechanical equipment should be completed, including 90% of the fire protection for the Basic chemical and nuclear equipment, in accordance with the safety classification.
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must represent low technical, cost, and/or schedule risk to the project. • Procedures for alarms, evacuation, fire watches, and emergency response should be completed.
6c Mechanical – Ventilation – Confinement	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the COR. • The multilayer strategy for containment (radiation and fluids) and confinement (particulate) should be completed, including active vs. passive, safety classification, defense in depth, and single failure. • The controls for the interface with the ventilation system should be completed. • The safety classification of the ventilation subsystems should be completed. • The location of major ventilation equipment (air-handling units, intake and discharge plenums, stacks, et al.) should be completed and provided to layout.
	Preliminary Design	• The layout and hydraulic sizing should be completed. • The design of 60% of the mechanical equipment should be completed, including 90% of the ventilation system for the Basic chemical and nuclear equipment, and the containment–confinement system, in accordance with the safety classification.
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
7 Electrical	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the COR.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
		• The normal power supplies and emergency power supplies should be defined to prevent blackout. • The multilayer strategy for safety-related electrical systems should be completed, including defense in depth and single failure. • The location of major electrical equipment (substations, switchgear, motor control center room, et al.) should be completed and provided to layout.
	Preliminary Design	• The electrical design diagrams should be completed. • The design of 60% of the electrical equipment should be completed, in accordance with the safety classification.
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
8 Instrumentation and Controls (I&C)	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the COR. • The safety classification of I&C systems should be completed, including compliance with safety instrumentation levels criteria. • The multilayer strategy for safety-related I&C systems should be completed, including defense in depth and single failure.
	Preliminary Design	• The I&C design and P&ID diagrams should be completed. • The design of 60% of the I&C equipment should be completed, including 90% of the I&C for the basic chemical and nuclear equipment, in accordance with the safety classification; with a good interface with operations and human factor engineering.
	Final Design	• At the 90% design stage, calculations, analyses, reports, specifications, and drawings should be complete and issued. Any residual open items (e.g., reconciliation with procured equipment) must be evaluated, must be captured in a formal closure tracking system, and must pose low technical, cost, and/or schedule risk to the project.
9 ES&H	Conceptual Design	• The design and qualification codes, standards, criteria should be completed and entered into the COR. • Risk and Opportunity Assessment have been prepared to support the evaluation of the Safety-in-Design Strategy (SDS). • The SDS has been prepared and approved. • The portion of the safety analyses leading to the safety classification of the basic chemical and nuclear systems and the containment-confinement systems should be completed, accounting for nuclear, criticality, chemical, and environmental effects. • A Conceptual Safety Validation Report has been prepared. • A National Environmental Policy Act strategy has been completed.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
	Preliminary Design	• The detailed safety analyses for safety classification at the component level should be ongoing for all structures, systems, and components.
	Final Design	• The safety analyses should be completed, reviewed and approved, with no open items. • The Construction Project Safety and Health Plan has been prepared prior to construction.
10 Construction	Conceptual Design	• Construction should have reviewed and approved the layout plans, the excavation plans, the foundation plans, and the location of major buildings and equipment. • Construction should have approved the design codes and standards for building structures and major equipment for construction feasibility and qualifications of construction personnel and contractors.
	Preliminary Design	• Construction should have reviewed and approved the 60% layout and drawings for constructability.
	Final Design	• Construction should have reviewed and approved the 90% layout and drawings for constructability.
11 Operations	Conceptual Design	• Operations should have reviewed and approved the 30% design of the process/system design, the plant layout, the I&C design, and the emergency preparedness.
	Preliminary Design	• Operations should have reviewed and approved the 60% design of the process/system design, the plant layout, the I&C design, and the emergency preparedness.
	Final Design	• Operations should have reviewed and approved the 90% design of the process/system design, the plant layout, the I&C design, and the emergency preparedness.
12 Inspections and Maintenance	Conceptual Design	• Inspection and maintenance should have reviewed and approved the 30% design of the materials, mechanical, electrical, and I&C disciplines for the feasibility of access for inspections, tests, and repair/replacements.
	Preliminary Design	• Inspection and maintenance should have reviewed and approved the 30% design of the materials, mechanical, electrical, and I&C disciplines for the feasibility of access for inspections, tests, and repair/replacements.
	Final Design	• Inspection and maintenance should have reviewed and approved the 30% design of the materials, mechanical, electrical, and I&C disciplines for the feasibility of access for inspections, tests, and repair/replacements.
13 Security and Emergency Response	Conceptual Design	• The design and qualification codes, standards, and criteria should be completed and entered into the COR. • An emergency-management program has been established in accordance with DOE O 151.1D. • Safeguards and security requirements have been identified if security is part of the project scope.
	Preliminary Design	• An emergency-management program has been developed in accordance with DOE O 151.1D.

Discipline	Design Phase: Conceptual 0% to ~30%. Preliminary ~30% to ~60%. Final ~90% to 100%.	Expectation (What should be completed at each design phase)
		• A preliminary security-vulnerability assessment has been conducted.
	Final Design	• An emergency-management program has been developed and updated in accordance with DOE O 151.1D. • A Security Vulnerability Assessment Report has been finalized.
All Disciplines	Conceptual Design	• The COR has been prepared with input from all disciplines. • Conceptual Design Report has been prepared with input from all disciplines. • For a nuclear project, NQA-1 standards have been implemented. • The design organization shall prepare and implement a Configuration Management Plan as an integrated process for all activities that affect safety-in-design integration as the project moves from design to operation.
	Preliminary Design	• The COR has been placed under configuration control. • The Preliminary Design Report has been prepared. • Preliminary safety results have been documented for review in accordance with DOE-STD-1189-2016. • QA program has been updated for preliminary design. • A Configuration Management plan has been approved prior to start of preliminary design activities.

	Final Design	Activities include
		• Complete final drawings and specifications that may be released for bid and/or construction
		• A current and detailed cost estimate
		• A current construction schedule
		• Clearly defined testing requirements and acceptance criteria for the safety and functionality of all subsystems
		• Independent technical, construction, operation, and environmental reviews of the final drawings and specifications
		• A quality-control review that evaluates both technical accuracy and discipline coordination
		• A final design that meets all the requirements stipulated in the COR
		• A final-design review, consisting of
		  o final validation of comment resolution from previous reviews, and a review of any additional developments since the last review
		  o Checking and verification of any required waivers or exemptions
		• All required design and safety basis documents have been developed or updated for final design phase.
		• The QA program has been updated for final design, construction, and procurement activities.

3 Conduct of the Design Review Process

At each design phase, the Design Review process should be conducted within the following general principles:

1. The Design Review Team (DRT) should have a chair, a vice chair, and a secretary.

2. The scope of the Design Review should be stated in terms of

    a. The design phase (conceptual, preliminary, and final) and corresponding percent of design completion (i.e., 30%, 60%, or 90%).

    b. The physical boundaries of scope to be reviewed (facility, buildings, units, systems, subsystems, et al.) including building drawings, flow diagrams, P&IDs, electrical diagrams, and ventilation diagrams, indicating the scope of the design review.

    c. Which of the 13 disciplines in Table 3 will be involved in the Design Review.

3. The DRT should be composed of at least two subject-matter experts (SMEs) in each of the 13 disciplines identified in Table 1, unless the discipline is excluded from a particular review for reasons agreed-upon by the Design Review chair and DOE. Additional DRT members who are not assigned as SMEs for one of the 13 disciplines should be assigned only with the chair's and DOE's approval.

4. The Engineering Design Team (EDT) should have a chair and a vice chair, and should provide the list of the discipline SMEs to the DRT chair to communicate to their DRT counterparts.

5. The EDT should provide to the DRT a design plan indicating the overall design strategy, the project-specific design standards, and the design schedule with the list of design activities with their progress status, and the list of completed and in-progress design documents, by discipline.

6. The EDT should provide the design documents to be reviewed in advance, with sufficient time for the DRT to review the documents prior to the Design Review meeting.

7. The Design Review kickoff meeting should start with a common multidisciplinary presentation by the EDT to cover, as a minimum, the scope and

agenda of the review, the design documents to be reviewed, and the design status (work completed, work in progress, work not initiated).

8. At the kickoff meeting, the DRT chair should outline expectations, the Design Review charter, operating procedures, and the documentation of the proceedings, as well as the processes for submittal of DRT requests for information, responses by the EDT, and acceptance by the DRT.

9. The kickoff should be followed by breakout sessions by discipline.

10. The DRT should structure its review along the LOIs in Appendix A, plus other project-specific questions, at the discretion of the DRT SMEs.

11. Each DRT discipline review should track their questions, responses, additional requests for information, and open items, and should provide them to the DRT secretary.

12. The Design Review should conclude with a common multidisciplinary meeting in which each discipline would report their conclusions, open items, and path forward.

13. The DRT secretary should compile the DRT reports by discipline and the requests for information.

14. Where there are differences of opinions among the DRT, or between the DRT and the EDT, the DRT chair will work to resolve them and achieve consensus.

15. The DRT report would be circulated to the DRT and the EDT for review and comments before formal issue.

16. Once the EDT has responded to all requests for information to the satisfaction of the DRT, the final Design Review report is prepared by the Secretary, reviewed by the DRT, and signed by the DRT chair.

Appendix A Lines of Inquiry (LOI) for Design and Engineering Review

This appendix contains 24 sets of LOIs [3] developed for design and engineering review. The LOIs were developed to reflect the DOE Orders, Guides, and Technical Standards published in 2018. Additional engineering and technical areas can be added in the future in response to lessons learned or Best Engineering Practices (BEPs) from onsite reviews. The following table provides a brief description of the LOIs and it is followed by the detailed LOIs for the subject areas.

For specific design review, the Design Review Team should determine which of the LOIs are appropriate for the different phases in the design process—that is, conceptual, preliminary, and final, or at different percent of design completion: 30, 60, 90, and 100 percent. Also, additional LOIs should be developed based on the specific design.

Table 5. Lines of Inquiry (LOI) Sets.

Set	Subject	Description
1	Siting Criteria	This set of LOIs provides for the review of the nuclear siting criteria for new facility siting and design.
2	Nuclear	This set of LOIs provides for the review of the nuclear design criteria to ensure that DOE hazard category 1, 2, and 3 nuclear facilities are designed, constructed, operated, and dispositioned in a manner that ensures adequate protection to the public, workers, and the environment from nuclear hazards. Additional nuclear safety basis LOIs are contained in the SRP (5 volumes) on Safety Basis Program Review.
3	Natural Phenomena Hazards and Structural Engineering	This set of LOIs provides for the review of the natural phenomena hazards (NPHs) and related structural engineering and safety criteria. The NPHs include seismic, wind, fire, flood, and other external events.
4	Fire Protection	This set of LOIs provides for the review of the fire protection programs and fire safety design of DOE nuclear facilities.
5	Criticality	This set of LOIs provides for the review of the criticality safety design and operational programs for nuclear facilities and activities to ensure adequate protection to the public, workers, and the environment.
6	Mechanical	This set of LOIs provides for the review of the design and operations of mechanical equipment classified as safety-significant or a safety class that provide both passive and active safety functions. The mechanical equipment includes confinement ventilation and HEPA filters of nuclear facilities.
7	Electrical	This set of LOIs provides for the review of the electrical design and electrical safety programs to provide power to systems and components that require electrical power in order to perform their safety functions, and to provide a sound and effective approach to electrical safety to ensure the safety of facility workers.

3 The abbreviations and acronyms contained in the LOIs are defined in a list that begins on page v.

Set	Subject	Description
8	Instrument and Control	This set of LOIs provides for the review of the design, procurement, installation, testing, maintenance, operation, and quality assurance of safety instrumented systems (SIS) that are used at DOE nuclear facilities.
9	Radiation Protection	This set of LOIs provides for the review of the radiological protection design and program to (1) minimize personnel external and internal exposures to radioactive materials; (2) provide adequate radiation posting, sampling, monitoring, and notification or alarm capabilities; and (3) apply ALARA principles. Radiation protection should be provided through facility physical design, and a program must be implemented for facility operation and disposition.
10	Hazardous Materials	This set of LOIs provides for the review of the design and implementation hazardous materials programs (radioactive materials and chemicals) to minimize the risk to the worker, public and environment.
11	Sustainability	This set of LOIs provides for the review of the high performance and sustainable building principles applicable to the siting, design, construction, and commissioning of new facilities and major renovations of existing facilities.
12	Human Factors	This set of LOIs provides for the review of the human factors engineering and criteria applicable to the design, operation, and maintenance of DOE nuclear facilities.
13	Security	This set of LOIs provides for the review of the safeguards and security review based on the requirements and guidance of DOE O 413.3B, DOE G 413.3-3, and DOE 470-series directives for safeguards and security and the 205 series of DOE directives for cybersecurity.
14	Pressure Safety	This set of LOIs provides for the review of the pressure safety design and programs in support of worker safety and facility safety. Commercial standards, such as ASME Boiler and Pressure Vessel codes, are invoked by DOE regulations and directives for the design of process equipment with pressure safety significance.
15	Environmental Protection	This set of LOIs provides for the review of the application of the DOE National Environmental Policy Act (NEPA) process during nuclear facility design phases and the development and implementation of the Environmental Management System.
16	Emergency Preparation	This set of LOIs provides for the review of the Emergency Management System which provides the framework for the development, coordination, control, and direction of all emergency planning, preparedness, readiness assurance, response, and recovery actions.
17	Technology Readiness Assessment	This set of LOIs provides for the review of the Technology Readiness Assessments (TRAs) and the development of the Technology Maturation Plans (TMPs) during DOE nuclear facility design. The TRAs and TMPs activities are tools to assist in identifying technology risks and enable the correct quantification of scope, cost, and schedule impacts in the project.
18	Waste Management	This set of LOIs provides for the review of the design and operation of waste management systems in a manner that is protective of worker and public safety and the environment.
19	D&D Considerations	This set of LOIs provides for the review of the nuclear facility design to facilitate ultimate deactivation, decontamination, and decommissioning.
20	Systems Engineering	This set of LOIs provides for the review of the systems engineering during facility design and construction and the implementation of the System Engineer Program for nuclear facility operations and maintenance.
21	Configuration Management	This set of LOIs provides for the review of the configuration management program to ensure that it (1) has been established and documented; and (2) is being effectively implemented to ensure the adequacy of the structures, systems, and components (SSCs) and documentation relied upon for the protection of the public, the workers, and the environment.
22	Nuclear Maintenance Management Program	This set of LOIs provides for the review of nuclear maintenance management programs of the entire life cycle of the DOE nuclear facilities. DOE O 433.1B defines the safety management program for maintenance and the reliable performance of structures, systems, and components (SSCs). DOE O 430.1B provides maintenance program requirements from the perspective of real property management.
23	Plant Layout	This set of LOIs provides for (1) the review of the plot plan and plant layout drawings and the location and size of major buildings, (2) the verification of their capacity to accommodate the

Set	Subject	Description
		process and supporting systems, (3) the layout of major equipment, and (4) arrangements for principal and supporting structures, systems, and components, while providing for safe protection of the control rooms, and access for inspections and maintenance.
24	Materials and Corrosion	This set of LOIs provides for the review of the material selections and corrosion control for each structure, system, and subsystem, equipment, and component to sustain the operating and design conditions for the design life of the SSC.

LOI Set 1: Siting Criteria [4]

	Set 1: Siting Criteria Lines of Inquiry (LOIs)	Reference
1	Have the site boundary and land-use of the site surroundings been considered? Note: This includes properties at risk from accidental exposures, public exclusion zones, distances from population centers, and population density.	DOE G 420.1-1A [5] Section 5.1.2
2	Has the proximity of fire departments and emergency medical centers been considered?	DOE G 420.1-1A Section 5.1.2
3	Have the utility systems essential to support safety-class structures, systems, and components, such as electrical power supply and water supply, been considered?	DOE G 420.1-1A Section 5.1.2
4	Have the physical characteristics of the site, including topography, meteorology, and hydrology, been considered?	DOE G 420.1-1A Section 5.1.2
5	Have the geological and subsurface elements been considered? Note: This includes the potential for fault rupture and the severity of vibratory ground motions from earthquakes, soil-bearing design capacity, rock or other bearing stratum, ground settlement, and groundwater elevations.	DOE G 420.1-1A Section 5.1.2
6	Have the natural phenomena hazards as discussed in DOE O 420.1C been considered? Note: This includes earthquakes, volcanic ejection, wind, flood, snow, hail, precipitation, and lightning.	DOE G 420.1-1A Section 5.1.2
7	Have emergency response considerations, including population sheltering or shielding parameters, evacuation delay times, and rates for the public and colocated workers, been considered?	DOE G 420.1-1A Section 5.1.2
8	Have potential human-induced hazards from nearby facilities or activities, such as industrial and military facilities, aircraft impacts, pipelines, and transportation routes, been considered?	DOE G 420.1-1A Section 5.1.2
9	Have the proximity and hazard to other nearby facilities been considered?	DOE G 420.1-1A Section 5.1.2
10	Have site-related assumptions for the EIS been considered?	DOE G 420.1-1A Section 5.1.2
11	Are the facility fence and exclusion areas well-mapped and defined?	Best Engineering Practice (BEP) [6]
12	Are there hazardous chemicals, fire, or explosive materials stored onsite or nearby?	BEP
13	Is the site meteorology characterized, including local climatology; precipitations; thunderstorms; lightning; wind speeds and directions (plume dispersion); tornado potential; droughts (loss of cooling source); hail; ice and snow; temperature; and humidity (for the design of the HVAC systems)?	BEP
14	Is the site hydrology characterized, including probable maximum flood on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami hazards, ice and snow effects, low-water considerations, and groundwater?	BEP

[4] DOE G 420.1-1 specifies that radiological siting criteria of 25 rem, 50-year effective dose equivalent must be used, from releases over the course of postulated design basis accidents from uptakes at the site boundary that could be delivered during a one-year period.

[5] This DOE guide, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2 and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

[6] Based on lessons learned from DOE and commercial engineering practices.

	Set 1: Siting Criteria Lines of Inquiry (LOIs)	Reference
15	Is the geological, seismological, and geotechnical engineering characterization of the site completed?	BEP
16	Are the site soil properties and layering characteristics defined?	BEP
17	Are ground faulting and seismic features characterized?	BEP
18	Has the natural and seismic stability of subsurface materials, foundations, and slopes characterized?	BEP
19	Is the seismic hazard analysis completed and peer-reviewed (source terms, attenuation functions) in order to develop the seismic ground motions?	BEP
20	Is the control room located and designed to sustain without damage the design-basis internal or external accidents?	BEP

LOI Set 2: Nuclear Safety Design [7]

	Set 2: Nuclear Safety Design Lines of Inquiry (LOIs)	Reference
1	Is safety integrated early into the design process and throughout the design process, consistent with DOE–STD-1189?	• DOE O 420.1C, Chg 1 [8], Attachment 2, Chapter I, Section 3a(1) • DOE G 420.1-1A [9], Section 4
2	During the preliminary design process, has the DOE approved the nuclear safety design criteria for preparing the preliminary documented safety analysis (PDSA), unless the contractor uses the design criteria specified in DOE O 420.1C?	10 CFR 830, Subpart B, §830.206
3	Are safety analyses used to identify • safety-class and safety-significant structures, systems, and components (SSCs)? • safety requirements of the safety-class and safety-significant SSCs? • specific administrative controls (SACs) needed to fulfill safety functions?	DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3a(2)
4	Does the nuclear facility design follow the principles of defense-in-depth (DID)?	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(2) • DOE G 420.1-1A, Section 5.1
5	Are the DID principles applied to the design, including • appropriate site selection? • minimization of material-at-risk? • conservative design margins? • quality assurance? • multiple physical barriers? • multiple means to achieve safety functions? • equipment and administrative controls? • accident release monitoring? • emergency planning?	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(2) • DOE G 420.1-1A, Section 5.1
6	Has the following hierarchy of control been applied to address hazardous-material release events at all stages of design development? 1. Minimization of hazardous materials 2. Safety-SSCs preferred over administrative controls 3. Passive SSCs over active SSCs	• DOE G 420.1-1A, Section 5.2 • DOE-STD-1189

[7] The LOIs related to the development and implementation of the nuclear safety basis programs are in the *SRP on Safety Basis Program Review* (5 volumes), which covers design, operations, disposition, and environmental restoration.

[8] DOE O 420.1C, Chg 1, February 27, 2015, establishes facility and programmatic safety requirements for the DOE, including the NNSA, for (1) nuclear safety design criteria; (2) fire protection; (3) criticality safety; (4) natural phenomena hazards (NPH) mitigation; and (5) Cognizant system engineer (CSE) program.

[9] DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

	Set 2: Nuclear Safety Design Lines of Inquiry (LOIs)	Reference
	4. Preventive controls over mitigative controls 5. Facility safety SSCs over personal protective equipment	
7	Are radioactive material confinement design considerations included in the overall facility design? Note: Nuclear facilities with uncontained radioactive material (as opposed to material determined by safety analysis to be adequately contained within drums, grout, or vitrified materials) must have the means to confine the uncontained radioactive materials to minimize their potential release in facility effluents during normal operations, accidents, and after accidents.	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(3) • DOE G 420.1-1A, Section 5.3 • DOE-HDBK-1132-99 [10], Sections 1.1 and 1.2
8	Has the nuclear facility design integrated with other design requirements, such as explosive safety, industrial safety, and nuclear explosive safety? Note: See DOE-STD-1189 for Safety Program and other Important Project Interfaces	DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(11)
9	Has the facility design included considerations for human factors engineering principles and criteria?	DOE G 420.1-1A, Section 5.4.9
10	Has the facility design included considerations for support systems, design interface, and system interaction?	DOE G 420.1-1A, Section 5.4.10
11	Has the facility design included considerations of mechanical handling equipment (cranes, manipulators, et al.) to determine if their failure would create hazardous-material release exceeding the guidelines for determining safety-class or safety-significant classification?	DOE G 420.1-1A, Section 5.4.11
12	Has the nuclear facility design included other general design considerations and practices, including • facilitate deactivation, decontamination, and decommissioning? • facilitate inspection, testing, and maintenance? • radiation protection and contamination control? • access control? • nonradioactive hazardous-materials protection? • effluent monitoring and control? • waste management and storage systems? • emergency preparedness and emergency communications? • human factors? • support systems and system interfaces? • mechanical handling equipment? • ventilation systems? • environmental qualifications? • electrical systems? • instrumentation, controls, and alarm systems? • determining the set of Codes and Standards to establish the Code of Record and the design criteria?	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b • DOE G 420.1-1A, Sections 5.4.1 to 5.4.16
13	Are the safety-SSCs designed to perform their safety functions as determined by the safety analyses?	DOE O 420.1C, Chg 1, Attachment 3, Section 3

[10] The Design Considerations Handbook, published in April 1999 and reaffirmed in 2014, provides information and suggestions for the design of systems typical to nuclear facilities, information specific to various types of special facilities, and information useful to various design disciplines.

	Set 2: Nuclear Safety Design Lines of Inquiry (LOIs)	Reference
14	Have the general design criteria that have been used addressed • conservative design margin? • system reliability? • environmental qualification? • safe failure modes? • protection against fire? • quality assurance, as required by 10 CFR Part 830, Subpart A, and DOE O 414.1D?	DOE O 420.1C, Chg 1, Attachment 3, Section 3.a
15	Have the general design criteria used addressed the selection and use of an appropriate set of applicable codes and standards to provide assurance that the SSCs are designed to perform their intended functions?	DOE O 420.1C, Chg 1, Attachment 3, Section 3.b
16	Are the codes and standards listed in Attachment 3 of DOE O 420.1C used for the following design areas? If not, are justifications provided? • Structural design • Mechanical and process equipment • Ventilation • Mechanical handling equipment • Electrical • Instrumentation, control, and alarm systems • Fire protection	DOE O 420.1C, Chg 1, Attachment 3, Section 3.b tables of codes and standards
17	Are active safety-class systems designed to meet single-failure criterion?	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(7) • DOE G 420.1-1A, Section 5.4.14 • DOE G 420.1-1A, Appendix A, *Single Failure*, page A-6
18	Are the SSCs and safety software designed to perform their safety functions when called upon, and to meet the quality assurance program requirements of either 10 CFR 830, Subpart A, or DOE O 414.1D?	• DOE O 420.1C, Chg 1, Attachment 2, Chapter I, Section 3b(6) • DOE G 420.1-1A, Section 5.4

LOI Set 3: Natural Phenomena Hazards [11]

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
1	Do the NPH design criteria satisfy the requirements and criteria of DOE-STD-1020-2016?	DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
2	Does the NPH analysis and design process involve the following steps? Step 1 Select a site that minimizes NPH hazards to the extent possible. Step 2 Establish NPH requirements for the site. Step 3 Identify the safety SSCs based on the safety basis evaluations. Step 4 Identify other SSCs that could impact the safety functions of the safety SSCs. Step 5 Establish performance criteria and NPH categorization for the identified SSCs. Step 6 Design the identified SSCs to ensure functionality in NPH events identified in Step 2 based on the NPH Design Category (NDC) of the SSCs established in Step 5.	• DOE-STD-1020-20 16, Chapters 1 and 2 • DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
3	Are the NDCs assigned based on unmitigated failure consequences, using the criteria in Table 2-1 of DOE-STD-1120-2016?	DOE-STD-1020-2016, Chapter 2
4	Do the safety functions include the following safeguards? • Confinement/containment of hazardous materials • Protection of occupants and collocated workers of the facility and the public • Continued operation of essential facilities and equipment • Safe shutdown of hazardous facilities and equipment • Maintenance of personnel access to areas needed for responding to accidents during NPH events	DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
5	During conceptual design stage, is the preliminary assessment of the appropriate NPH design basis for the facility structure and major-hazard controls documented in the Conceptual Safety Design Report?	DOE-STD-1189-1120, Appendix C
6	Is the NPH analysis supporting design documented, including evaluations of • potential damage to and failure of safety SSCs resulting from both direct and indirect NPH events? • common cause/effect and interactions resulting from failures of other nearby facilities or other SSCs in the same facility caused by, or induced by, an NPH event?	DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
7	Are the structures, systems, and components (SSCs) designed to performed their intended safety functions under the combined effects of NPH and normal loads as defined in the applicable building codes?	DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
8	Are these building codes contained in the facility Code of Records (CORs)?	• DOE O 420.1C (Chg 1), Attachment 2, Chapter IV • DOE O 413.3B • DOE-STD-1189-2016

[11] Refer also to the SRP on Seismic Design Expectation for similar or additional LOIs developed to support project Critical Decision approvals. This report is contained in the 2nd Edition of the SRP on the application of DOE O 413.3B and DOE-STD-1189 requirements published in March 2010.

[12] Include structural engineering LOIs.

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
Seismic Design LOIs		
9	Are the SSCs categorized and assigned seismic limit states according to DOE-STD-1120-2016 criteria and the methodology given in ANSI/ANS-2.26-2004 (R2010)?	DOE-STD-1020-2016, Chapter 3, Section 3.1
10	Are seismic design category 3 (SDC-3), SDC-4, and SDC-5 SSCs designed to the criteria of ASCE/SEI 43-05 and ASCE 4-98?	DOE-STD-1020-2016, Chapter 3, Section 3.1
11	Are the SSCs having a confinement and leak-tightness safety function designed to limit state C or D to meet the intent of ANSI/ANS-2.26-2004 (R2010)? Note: These SSCs may be assigned to limit state B if the functional requirements are those described for the SSC Type "Confinement barriers and systems containing hazardous material" for limit state B in ANSI/ANS-2.26-2004 (R2010), Appendix B.	DOE-STD-1020-2016, Chapter 3, Section 3.1
12	Are the SDC-1 and SDC-2 SSCs designed according to the criteria of IBC-2015, for Risk Category II and Risk Category IV facilities, respectively, and using the response coefficients in Table 3-1 of DOE-STD-1020-2016?	DOE-STD-1020-2016, Chapter 3, Section 3.1
13	For SDC-3 through SDC-5 SSCs, are the design basis earthquake (DBE) return period and appropriate design factors given in ASCE/SEI 43-05 used to determine the seismic ground motion applicable for the facility site?	DOE-STD-1020-2016, Chapter 3, Section 3.2
14	For SDC-1 and SDC-2 SSCs, are the return periods in IBC-2015 used?	DOE-STD-1020-2016, Chapter 3, Section 3.2
15	For SDC-3 through SDC-5 site characterization for seismic-related hazards, are the ANSI/ANS-2.27-2008 criteria followed, with the qualifications listed in DOE-STD-1020-2016?	DOE-STD-1020-2016, Chapter 3, Section 3.3
16	For SDC-1 and SDC-2 SSCs, is site characterization performed in accordance with IBC-2015?	DOE-STD-1020-2016, Chapter 3, Section 3.3
17	In regards to site-specific probabilistic seismic hazard analysis (PSHA), for SDC-3 through SDC-5 SSCs, are the criteria of ANSI/ANS-2.29-2008 used?	DOE-STD-1020-2016, Chapter 3, Section 3.4
18	For SDC-1 and SDC-2 SSCs located (1) on a site having facilities designed SDC-3 or higher, and (2) where a site-specific PSHA performed in accordance with ANSI/ANS-2.29-2008, are the resulting site-specific ground motions used, since they are acceptable?	DOE-STD-1020-2016, Chapter 3, Section 3.4
19	For the building and equipment response analysis to determine seismic demand for SDC-3 through SDC-5 SSCs, are the provisions of ASCE 4-98 used, with the exception listed in DOE-STD-1120-2016?	DOE-STD-1020-2016, Chapter 3, Section 3.5
20	For new facility design, does the method for determining design-basis seismic ground motion satisfy the requirements of Section 2 of ASCE 2 of ASCE/SEI 43-05 and Section 2 of ASCE 4-98?	DOE-STD-1020-2016, Chapter 3, Section 3.5
21	In performing dynamics response analyses and generating in-structure response spectra, are the ASCE 4-98 requirements met, provided these requirements are consistent with the ASCE/SEI 43-05 requirements?	DOE-STD-1020-2016, Chapter 3, Section 3.5
22	In regards to building and equipment capacity evaluation, are the following five steps being taken to develop a design that minimize the adverse consequences of earthquakes? Step 1 Provide a continuous and traceable load path from the SSC to foundation. Step 2 Ensure that applicable loads and load combinations are accounted for. Step 3 Provide redundant structures or structural elements that can redistribute loads when one structural element is overloaded. Step 4 Provide ductile elements and connections that can undergo deformations beyond yield without sudden and catastrophic collapse.	DOE-STD-1020-2016, Chapter 3, Section 3.6

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
	Step 5 Anchor mechanical equipment on roofs to resist specified seismic loads.	
23	In regards to the evaluation of the adequacy of an SSC to withstand seismic demands combined with other applicable concurrent loads, is the ratio of the total demand (D) to the SSC capacity (C) computed to code requirements, with the computed D/C value not exceeding unity?	DOE-STD-1020-2016, Chapter 3, Section 3.6
24	Are the nonstructural elements attached to the supporting structure designed to allow for seismic deformations of the structure without causing excessive damage to the structure?	DOE-STD-1020-2016, Chapter 3, Section 3.6
25	Is the seismic qualification of equipment performed by testing and/or by using actual earthquake experience or generic shake-table test, subject to ASCE/SEI 43-05, ASME QME-1 and DOE/EH-0545?	DOE-STD-1020-2016, Chapter 3, Section 3.6
26	In designing attachments for the distribution lines, is sufficient flexibility provided between the distribution line support so the distribution system can withstand the postulated relative displacement during a design-basis seismic motion?	DOE-STD-1020-2016, Chapter 3, Section 3.6
27	As part of seismic design, is instrumentation or another means included to detect and record the occurrence and severity of seismic events?	DOE O 420.1C (Chg 1), Attachment 2, Chapter IV
Wind, Tornado, and Hurricane Design LOIs		
28	Is the design categorization process and criteria in ANSI/ANS-2.26-2004 (R2010) used for wind design categorization?	DOE-STD-1020-2016, Chapter 4, Section 4.1
29	Has the design considered the following wind hazards? • Extreme straight-line winds • Hurricane winds • Tornado winds • Tornado atmospheric pressure change • Tornado-generated missiles • Hurricane-induced water surges • Wind-borne water impingement • Hurricane-generated missiles Note: If a new facility is to be constructed on a site with existing wind-hazard analyses, then the wind hazard analysis used for the new facility design shall conform to the requirements of DOE-STD-1020-2016, and not to the old requirements.	DOE-STD-1020-2016, Chapter 4, Section 4.1
30	Is the design of barriers and other SSCs designed using stress, strain, or deformation limits appropriate for the protective function and the failure mode of the barrier? Note: These barriers are to protect safety SSCs against damage from extreme wind or wind-driven missiles.	DOE-STD-1020-2016, Chapter 4, Section 4.1
31	Are the wind design category-1 (WDC-1) and WDC-2 SSCs designed for extreme wind-related hazards, using the criteria given in IBC-2015 for Risk Category II and Risk Category IV facilities, respectively?	DOE-STD-1020-2016, Chapter 4, Section 4.1
32	For the design of WDC-3, WDC-4, and WDC-5 SSCs, are site-specific wind design parameters determined based on the guidelines and criteria of DOE-STD-1120-2016, ANSI/ANS-2.3-2011, or the site-specific Probabilistic Wind Hazard Assessment (PWHA)?	DOE-STD-1020-2016, Chapter 4, Section 4.1
33	For site characterization for wind-related hazard, do the WDC-3, WDC-4, or WDC-5 SSCs designs follow the guidelines and criteria of DOE-STD-1120-2016 or those in ANSI/ANS-2.3-2011 (R2016)?	DOE-STD-1020-2016, Chapter 4, Section 4.2

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
34	Do the extent and quality of meteorological data collected to characterize wind-related hazards meet • the requirements of IBC-2015 for determining the design basis for extreme straight-line and hurricane wind speed? • the criteria of ANSI/ANS-2.3-2011 (R2016) for tornado wind speed, tornado APC, and missiles caused by tornados, hurricanes, and extreme winds? Note: Facilities with only WDC-1 and/or WDC-2 SSCs may be characterized using the requirements of IBC-2015, with wind data collected as needed for defining the IBC-2015 design parameters.	DOE-STD-1020-2016, Chapter 4, Section 4.2
35	Regarding the characterization of site meteorological data, is the information collected and analyzed on • facility location on the site? • size and orientation of other facilities on the site? • distances to offsite natural and manmade features that may affect wind hazards? • topographic and hydrologic features of the site and its environs?	DOE-STD-1020-2016, Chapter 4, Section 4.2
36	Are the DOE-STD-1020-2016 guidelines and criteria used for site-specific PWHA?	DOE-STD-1020-2016, Chapter 4, Section 4.2, Subsection 4.2.3 and 4.3
37	For design of WDS-3, WDC-4, or WDC-5 SSCs, is a site-specific PWHA performed, using the guidelines and criteria contained in DOE-STD-1120-2016?	DOE-STD-1020-2016, Chapter 4, Subsections 4.3.2 and 4.3.3
38	For the SSC design to mitigate wind-related hazards, are the following general design criteria used? • Provide a continuous and traceable load path from the SSC interface to foundation. • Ensure that applicable loads and load combinations are accounted for. • Provide redundant structures or structural elements that can redistribute loads when one structural element is overloaded. • Provide ductile elements and connections that can undergo deformations beyond yield without sudden and catastrophic collapse. • Provide missile-resistant walls and roof elements. • Anchor mechanical equipment on roofs to resist specified wind and missile loads. • Minimize or eliminate the potential for wind-borne missiles.	DOE-STD-1020-2016, Chapter 4, Section 4.4
39	For the design of SSCs in Categories WDC-3, WDC-4, and WDC-5, are the guidelines and criteria listed in DOE-STD-1020-2016 used?	DOE-STD-1020-2016, Chapter 4, Section 4, Subsection 4.42
Flood, Seiche, and Tsunami Design LOIs		
40	For flood design categorization, are the guidelines and criteria, including the return periods for Design Basis Floods, provided in DOE-STD-1020-2016 used? Note: The ANSI/ANS-2.26-2004 (R2010) design categorization process and criteria for seismic hazards shall be used for flood design categorization.	DOE-STD-1020-2016, Chapter 5, Section 5.1
41	For a new facility to be designed and constructed on a site with an existing flood-hazard analysis, Does the flood-hazard analysis conform with the DOE-STD-1020-2016 guidelines and criteria?	DOE-STD-1020-2016, Chapter 5, Section 5.1
42	Are the guidelines and criteria of DOE-STD-1120-2016 used for the development of the probabilistic flood hazard assessment (PFHA)?	DOE-STD-1020-2016, Chapter 5, Section 5.2
43	Are the following flood-related hazards evaluated as part of the flood design process? If so, are the DOE-STD-1020-2016 guidelines and criteria used?	DOE-STD-1020-2016, Chapter 5, Section 5.3

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
	• Stream and river flooding • Dam, levee, or dike failure • Storm surge • Tsunami • Seiche • Wave • Landslide • Volcano-created flood • Flood runoff • Change in groundwater level • Mudflow • Subsidence-induced flooding	
44	For determining the design basis flood level (DBFL) for facility with flood design category-3 (FDC-3), FDC-4, and FDC-5 SSCs, is a site-specific PFHA performed in the following two steps, and does it follow the guidelines and criteria of DOE-STD-1120-2016? • Perform a Flood Screening Analysis (FSA) to evaluate the magnitude of flood hazards that may affect the SSCs under consideration. Follow the guidelines of Subsection 5.4.1.2 of the standard. • If required based on the results and conclusions of the FSA, perform a Comprehensive Flood Hazard Assessment (CFHA). Follow the guidelines of Subsection 5.4.1.3.	DOE-STD-1020-2016, Chapter 5, Section 5.4, Subsection 5.4.1
45	Are the DOE-STD-1120-2016 guidelines and criteria used for determining the DBFL for facility with FDC-1 and FDC-2 SSCs?	DOE-STD-1020-2016, Chapter 5, Section 5.4, Subsection 5.4.2
46	For the FDC-1, FDC-2, FDC-3, FDC-4, and FDC-5 SSC design and evaluation to mitigate flood-related hazards, are the DOE-STD-1020-2016 guidelines and criteria followed regarding • general flood-design criteria? • design-basis flood level? • flood evaluation process? • flood design mitigation strategies? • flood-related hazard design criteria?	DOE-STD-1020-2016, Chapter 5, Section 5.5
Lightning Design LOIs		
47	Are the SSCs, that may be subject to the effects of lightning strikes, designed to withstand the effects of such strikes or to protect strikes in accordance with the NFPA-780-2017 criteria?	DOE-STD-1020-2016, Chapter 6
Precipitation Design LOIs		
48	For precipitation design categorization, are the guidelines and criteria provided in DOE-STD-1020-2016 used? Note: ANSI/ANS-2.26-2004 (R2010) for seismic hazards shall also be used for precipitation design categorization.	DOE-STD-1020-2016, Chapter 7, Section 7.1
49	For a new facility to be designed and constructed on a site with an existing precipitation hazard analysis, does the precipitation hazard analysis conform with the DOE-STD-1020-2016 guidelines and criteria?	DOE-STD-1020-2016, Chapter 7, Section 7.1
50	• Does the precipitation design categorization take into account all precipitation-related hazards applicable to the facility?	DOE-STD-1020-2016, Chapter 7, Section 7.1

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
	• Is the precipitation design coordinated with the flood design?	
51	Are the following principles applied for site characterization for precipitation-related design? • Precipitation, hydrologic characteristics, meteorological characteristics and topographical features of a site and its surroundings are investigated in sufficient scope and detail to obtain the data necessary for performing a Probabilistic Precipitation Hazard Assessment (PPHA). • The size of the region to be investigated and the type of data pertinent to the investigations are determined by the nature of the region (for example, upstream dams, hydrologic features) surrounding the proposed or existing site. • Site characterization and design and evaluation of SSCs are carried out to obtain the data necessary for performing a site-specific PPHA, in accordance with the Standard cited in the References column. • The characterization of site precipitation is carried out by a review of pertinent literature and field investigations, and follow the requirements given in Section 7.2.2 of the standard. • Data and other relevant information obtained from prior investigations should be used, supplemented by additional site-specific investigations, as deemed necessary by the SMEs.	DOE-STD-1020-2016, Chapter 7, Section 7.2
52	Does the determination of precipitation design parameters address site flooding caused by local precipitation?	DOE-STD-1020-2016, Chapter 7, Section 7.3
53	Do the PPHA and the determination of precipitation design parameters for design-basis precipitation flooding address the guidelines and criteria contained in DOE-STD-1102-2016?	DOE-STD-1020-2016, Chapter 7, Section 7.4
54	Do the SSC design and evaluation to mitigate precipitation-related hazards address the following precipitation design criteria determination steps? Step 1 Determine the design basis precipitation level (DBPL) for each precipitation-related hazard based on the applicable return period. Step 2 Evaluate the site's storm-water management system. Step 3 Develop a precipitation design strategy. Step 4 Design civil-engineering systems to carry out the strategy.	DOE-STD-1020-2016, Chapter 7, Section 7.5
Volcanic Eruption Design LOIs		
55	• Is the new facility located within ~250 miles of a volcanic center that erupted within 2.6 million years (Quaternary Period)? • If so, has the facility design included a volcanic hazard assessment (VHA)?	DOE-STD-1020-2016, Chapter 8
56	If the facility is located within ~60 miles of the Quaternary volcanic vent, does the VHA address the following hazards? • Ash fall • Lava flows • Ballistic projections • Pyroclastic flow • Mudflows • Low-level proximal seismic activity • Ground deformation • Tsunami • Atmospheric effects • Emission of toxic gases	DOE-STD-1020-2016, Chapter 8

	Set 3: Natural Phenomena Hazards (NPH) Lines of Inquiry (LOIs) [12]	Reference
57	Does the facility design address the DOE-STD-1020-2016 guidelines and criteria for onsite characterization of volcanic hazards?	DOE-STD-1020-2016, Chapter 8, Section 8.3
58	Does the facility design address the DOE-STD-1020-2016 design considerations for volcanic hazards?	DOE-STD-1020-2016, Chapter 8, Section 8.4
59	Does the Contract or the Request for Proposals (RFP) include an overview of the NPH design requirements for the facility?	Best Engineering Practice (BEP)
60	Does the Contract or the RFP reference any applicable site NPH-related standards and/or NPH analysis standards?	BEP
61	Does the Contract or the RFP stipulate any required geotechnical investigations and engineering to be performed in support of facility design, while referencing any pertinent existing information, such as geotechnical reports from nearby facilities, regional geotechnical data, et al.?	BEP
62	Does the Contract or the RFP define the expected peer reviews of geotechnical, structural, and seismic design, as well as the requirement for a Structural Summary Report?	BEP

LOI Set 4: Fire Protection

	Set 4: Fire Protection Lines of Inquiry (LOIs)	Reference
1	Does the design (drawings, specifications and related analyses considered together) delineate and conform to the governing fire protection criteria as defined in the References listed in the Reference column?	• 10 CFR Part 851, Appendix A, Paragraph 2, *Fire Protection* • 29 CFR Part 1910, Subpart L, *Fire Protection* • 29 CFR Part 1926, Subpart F, Fire Protection and Prevention • DOE O 420.1C, Chg 1 [13], Facility Safety, Chapter II • DOE-STD-1066-2016 [14], Fire Protection
2	Do site selection and facility design considerations reflect the evaluated capabilities of the local emergency-services organization (fire department) to respond in a timely and effective manner to all credible emergencies (for example, fire, emergency medical, and hazardous material)?	10 CFR Part 851, Appendix A, *Fire Protection*
3	Have the applicable requirements from the International Building Code (IBC), National Fire Protection Association (NFPA) Codes and Standards, and any state and local codes, been identified for the design of the fire-protection and emergency-response programs?	• DOE O 420.1C, Chapter II.3.a(2) • DOE O 420.1C, Attachment 1, *Contractor Requirements Document (CDR)* • DOE-STD-1066-2016, Section 2.2
4	Has DOE approval been obtained if there was a request for equivalencies and exemptions of fire-protection requirements, codes, and standards?	• DOE O 420.1C, Attachment 1, Sections 1.c and 2a • DOE O 251.1C, *Department Directives Program*
5	Have the applicable codes and standards been established and maintained in the Code of Record early in the design process (at the conceptual design stage)?	• DOE O 413.3B • DOE O 420.1C, Attachment 1, Section 1.c • DOE-STD-1189-2016
6	As part of the facility design process, has the contractor submitted a documented fire-protection program to the DOE for review and approval?	DOE O 420.1C, Chapter II.3.b(1)
7	Is the design of fire protection systems and components integrated with safety early and throughout the overall design process?	• DOE O 420.1C • DOE-STD-1189-2016, Appendix E.2 • DOE-STD-1066-2016, Section 4.1
8	• Are Fire Protection Engineers (FPEs) part of the design team to ensure that fire-protection requirements are documented and incorporated into design plans and specifications? • Is the FPE involvement in the design process early in the conceptual design phase and continued throughout the design process?	DOE-STD-1066-2016, Section 4.1

[13] DOE O 420.1C, Chg 1, February 27, 2015, establishes facility and programmatic safety requirements for the DOE, including the NNSA, for: (1) nuclear-safety design criteria; (2) fire protection; (3) criticality safety; (4) natural phenomena hazards (NPH) mitigation; and the (5) Cognizant system engineer (CSE) program.

[14] DOE-STD-1066-2016, provides acceptable methods and approaches for meeting DOE fire-protection program and design requirements and to address special or unique fire-protection issues at DOE facilities that are not comprehensively or adequately addressed in national consensus standards or other design criteria.

	Set 4: Fire Protection Lines of Inquiry (LOIs)	Reference
9	Do the design documents include fire-protection criteria based on either a Fire Protection Design Analysis or a Preliminary/Project Fire Hazard Analysis?	DOE-STD-1066-2016, Section 4.1
10	Is the nuclear facility classified as High Hazard occupancies, as defined in the IBC, unless a different classification is approved?	DOE-STD-1066-2016, Section 4.1
11	Are the general design criteria for Safety Significant (SS) and Safety Class (SC) for fire protection systems, as defined in DOE O 420.1C, Attachment 3, used for the design? If not, has the DOE reviewed and approved the exemptions and equivalencies?	• DOE O 420.1C, Attachment 3, *Design Criteria for Safety Structures, Systems, and Components* • DOE-STD-1066-2016, Appendix A, *Safety Significant and Safety Class Fire Protection System Specifications*
12	Are design criteria for SS and SC used for the design of wet-pipe sprinkler systems, water supply systems, and fire barriers?	DOE-STD-1066-2016, Appendix A, Sections A.2 to A.4
13	Are the following fire protection thresholds address as part of the design process? • Facilities over 5,000 sq. ft. of floor area must be of Type I or Type II construction. • Automatic fire-suppression systems must be provided throughout the facility or where a maximum possible fire loss exceeds $5 million. • Automatic fire-suppression systems must be provided o where required by the safety basis analyses o where there are significant life-safety hazards o where fire may cause unacceptable mission or program interruption	DOE O 420.1C, Chapter II.3.c(2)
14	Are the following fire protection and life safety systems addressed in the facility design? • Fire suppression • Fire barrier • Fire detection • Life safety • Water supply and distribution • Emergency notification	DOE O 420.1C, Chapter II.3.c(3)
15	Are the General Design Criteria cited in DOE-STD-1066-2016 applied to the fire protection design? These criteria include • significant modification of an existing facility • design and construction of new facility • multiple fire-protection approaches for property protection • facility layout and construction • building services • life safety • fire protection systems and equipment • fire detection and alarm systems	DOE-STD-1066-2016, Section 4.2
16	Have the applicable National Fire Protection Association (NFPA) Codes and Standards been applied to the following? • Gases • Combustible mists and vapors	DOE-STD-1066-2016, Section 4.3

	Set 4: Fire Protection Lines of Inquiry (LOIs)	Reference
	• Flammable and combustible liquids • Combustible dusts • Combustible metals • Furnaces • Carbon monoxide gas	
17	Have the applicable codes and standards been applied to the following DOE-specific facilities and systems? • Facilities containing radioactive and other hazardous materials • Glove boxes, hot cells and canyons • Nuclear confinement ventilation system fire protection	DOE-STD-1066-2016, Section 4.4
18	If the mission of the facility has special hazards that are special or unique to DOE, and the industry codes and standards do not address these hazards, does the fire-protection design address these hazards?	DOE O 420.1C, Chapter II.3.c(4)
19	Are Fire Hazards Analyses (FHAs) or fire-protection design analyses performed to support new construction or significant facility modifications?	• DOE O 420.1C, Chapter II.3.f(1) • DOE-STD-1066-2016, Section 4.1.1 • DOE-STD-1066-2016, Appendix B, *Fire Hazard Analysis* • DOE-STD-1189-2016, Appendix E.2
20	Are the FHA results addressed in the facility Conceptual Safety Design Report (CSDR) and Preliminary Documented Safety Analysis (PDSA) in a manner that reflects all relevant fire-safety objectives that could affect the facility safety basis?	DOE-STD-1189-2016, Appendix E.2
21	Does the fire-protection design process address wildland fire, if applicable?	• DOE O 420.1C, Chapter II.3.g • DOE-STD-1066-2016, Section 8

LOI Set 5: Criticality

	Set 5: Criticality Lines of Inquiry (LOIs)	Reference
1	Has the project developed, implemented, and maintained a nuclear criticality safety program (CSP) to support the facility design process?	DOE O 420.1C, Chapter III, Section 3.a
2	• Does the CSP document describe how the contractor will satisfy the requirements of the ANSI/ANS-8 series of nuclear criticality safety standards? • Are the criticality standards included in the Code of Record?	• DOE O 420.1C, Chapter III, Section 3.b • DOE-STD-3007-2017 [15] • DOE-STD-1158-2010 [16]
3	Does the CSP document explain why any recommendation in applicable ANSI/ANS-8 standards have not been implemented?	DOE O 420.1C, Chapter III, Section 3.b
4	Has the CSP document been submitted to and approved by DOE?	DOE O 420.1C, Chapter III, Section 3.c
5	Are the criticality safety evaluations (CSEs) conducted in accordance with DOE-STD-3007-2017, or by other documented methods approved by DOE?	• DOE O 420.1C, Chapter III, Section 3.d • DOE-STD-3007-2017
6	Do the CSE technical content and analyses comply with the required ANSI/ANS-8 standards?	DOE-STD-3007-2017, Chapter 3
7	Does the CSE process show interface with the Documented Safety Analysis (DSA) process from the earliest stages of project development?	• DOE-STD-3007-2017, Chapter 6 • DOE-STD-1189-2016, Appendix E.18
8	Does the CSE of the design basis events show interface with NPH and other design basis events?	DOE-STD-3007-2017, Chapter 3
9	Does the facility design address fissile material accumulation control to prevent accumulation of significant quantities of fissile material?	DOE O 420.1C, Chapter III, Section 3.e
10	Do the CSEs show that entire processes involving fissionable materials will remain subcritical under normal and credible abnormal conditions, including those initiated by design-basis events?	DOE O 420.1C, Chapter III, Section 3.f
11	Have the criteria and process for developing firefighting guidelines in areas within or adjacent to moderator-controlled areas been coordinated with the firefighting pre-incident plans and procedures?	DOE O 420.1C, Chapter III, Section 3.g
12	Has the contractor developed a written criticality safety policy during the design process?	• DOE-STD-1158-2010 [17], Chapter 1 • ANSI/ANS 8.19, Section 4.2
13	• During the design process, are criticality safety related performance metrics in place and used by management to monitor the effectiveness of the Criticality Safety Program? • Do the metrics provide clear indication of whether the program is improving? • Do the metrics encourage continuous improvement?	• DOE-STD-1158-2010, Chapter 1 • ANSI/ANS 8.19, Section 4.6

15 DOE-STD-3007-2017, *Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*, provides a framework for generating Criticality Safety Evaluations (CSE) supporting fissionable material operations at Department of Energy (DOE) nonreactor nuclear facilities.

16 DOE-STD-1158-2010, *Self-Assessment Standard for DOE Contractor Criticality Safety Programs*.

17 DOE-STD-1158-2010 provides a comprehensive set of lines of inquiry (LOIs) for assessing criticality safety programs. The review teams should also review these LOIs to determine their applicability for specific design reviews. The LOIs were developed under the major criteria of ANSI/ANS-8.19-2005, *Administrative Practices for Nuclear Criticality Safety.*

	Set 5: Criticality Lines of Inquiry (LOIs)	Reference
	• Do the criticality safety performance metrics encourage self-reporting of deficiencies? • Do the criticality safety performance metrics promote practices that prevent repeat criticality safety infractions of the same type or for the same operation or process? • Are the criticality safety performance metrics measurable and objective? • Do the criticality safety performance metrics encourage development of a strong staff and program by measuring performance?	
14	During the design process, are the facility and process information important to criticality safety being managed in accordance with the defined configuration management programs?	• DOE-STD-1158-2010, Chapter 1 • ANSI/ANS 8.19, Section 4.9
15	For the design of criticality safety equipment and processes, does the nuclear criticality safety (NCS) staff provide design input for all new or modified equipment?	• DOE-STD-1158-2010, Chapter 3 • ANSI/ANS 8.19, Section 6.1
16	Is the design input provided early enough to be incorporated without rework?	• DOE-STD-1158-2010, Chapter 3 • ANSI/ANS 8.19, Section 6.1
17	Does the NCS staff review and concur on final equipment and process designs?	• DOE-STD-1158-2010, Chapter 3 • ANSI/ANS 8.19, Section 6.1
18	Is an appropriate systematic and comprehensive hazard evaluation process used to identify credible upset conditions that could lead to a criticality accident?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
19	Does the evaluation demonstrate that no single credible event or failure can result in a criticality accident?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
20	Does this process consider hazards from natural-phenomena hazards, such as seismic and flooding?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
21	Are credible abnormal conditions identified in the safety-basis documents (for example, the DSA, BIO, and Transportation Safety Document) considered, as appropriate, in the process evaluations for criticality safety?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
22	Are firefighting scenarios considered—for example, addition of moderator, or displacement of fissionable material in water streams?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
23	Does this process incorporate criticality safety lessons learned?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
24	Does application of the double contingency principle involve unlikely changes in parameters, not simply failures of a control or other failures?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
25	Does NCS staff assist in developing overall Hazard Categorization of facilities as described in 10 CFR 830?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.1
26	Do criticality safety process evaluations emphasize the preferred order of controls—that is, first passive engineered controls, then active engineered controls, and finally administrative controls?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.2
27	Are controls developed for each contingency?	• DOE-STD-1158-2010, Chapter 5 • ANSI/ANS 8.19, Section 8.2
28	Is there a change control and document control system in place for criticality safety process evaluations?	• DOE-STD-1158-2010, Chapter 6 • ANSI/ANS 8.19, Section 9.3

	Set 5: Criticality Lines of Inquiry (LOIs)	Reference
29	Is the design of fissionable material storage areas consistent with ANSI/ANS-8.7, *Guide for Nuclear Criticality Safety in the Storage of Fissile Materials*?	• DOE-STD-1158-2010, Chapter 6 • ANSI/ANS 8.19, Section 9.5
30	Are practices dealing with control of moderators consistent with ANSI/ANS-8.22, *Nuclear Criticality Safety Based on Limiting and Controlling Moderators*?	• DOE-STD-1158-2010, Chapter 6 • ANSI/ANS 8.19, Section 9.5
31	Is the criticality accident alarm system designed to minimize false alarms?	• DOE-STD-1158-2010, Chapter 7 • ANSI/ANS 8.19, Section 10.1

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LOI Set 6: Mechanical Design

	Set 6: Mechanical Design Lines of Inquiry (LOIs)	Reference
1	For the design of the facility mechanical safety systems and components, are the following general design criteria being applied? • Conservative Design Margin. Safety structures, systems, and components (SSCs) must be designed with appropriate margins of safety. • System Reliability. Single Failure Criterion must be applied to safety class SSCs, and safety-significant SSCs must be designed to reliably perform all their safety functions. • Environmental Qualification. Safety-class SSCs must be designed to perform all safety functions with no failure mechanism; and safety-significant SSCs located in a harsh environment must be evaluated to establish qualified life. • Safe Failure Modes. Facility design must provide reliable, safe conditions and sufficient confinement of hazardous material during and after all design-basis accidents. • Support System and Interface Design. Support SSCs must be designed as safety-class or safety-significant SSCs if their failures prevent safety SSCs or specific administrative controls from performing their safety functions. Interfaces must be evaluated to identify SSC failures that would prevent safety-SSCs from performing their intended safety function. • Protection Against Fire. Safety-class systems must be designed with redundancy or other means, such that safety function is maintained for any postulated fire events that credit the safety-class systems. • Quality Assurance. A quality assurance program must be established.	• DOE O 420.1C, Chg 1, Attachment 3, Section 3a • DOE G 420.1-1A, Section 5.4
2	Does the mechanical design follow the principles of defense-in-depth (DID)?	• DOE O 420.1C, , Attachment 2, Chapter I, Section 3b(2) • DOE G 420.1-1A [18], Section 5.1
3	Do the DID principles applied to the design include the following? • Appropriate site selection • Minimization of material-at-risk • Conservative design margins • Quality assurance • Multiple physical barriers • Multiple means to achieve safety functions • Equipment and administrative controls • Accident release monitoring • Emergency planning	• DOE O 420.1C, Attachment 2, Chapter I, Section 3b(2) • DOE G 420.1-1A, Section 5.1
4	Does the mechanical design address and have provisions for • facilitating safe deactivation, decommissioning, and decontamination at the end of facility life, including incorporation of design considerations during the operational period that facilitate future decontamination and decommissioning?	DOE O 420.1C, Attachment 2, Chapter I, Section 3b(4)

[18] This DOE guide, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

	Set 6: Mechanical Design Lines of Inquiry (LOIs)	Reference
	• facilitating inspections, testing, maintenance, repair, and replacement of structures, systems, and components (SSCs) as part of a reliability, availability, and maintainability program, with the objective that the facility is maintained in a safe state? • keeping occupational radiation exposures within statutory limits and As Low As Reasonably Achievable (ALARA)?	
5	Are facility SSCs designed to withstand natural phenomena hazards (NPHs) and ensure • confinement of hazardous materials? • protection of occupants of the facility and the public? • continued operation of essential facilities? • protection of government property?	DOE O 420.1C, Attachment 2, Chapter IV, 3.a.(1)
6	Do the facility NPH design criteria satisfy the applicable requirements and criteria contained in DOE-STD-1020-2016, Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities?	DOE O 420.1C, Attachment 2, Chapter IV, 3.b
7	Do the facility NPH design criteria also satisfy the building codes for design to mitigate NPH events mandated by the local, city, county, and state regulatory authorities?	DOE O 420.1C, Attachment 2, Chapter IV, 3.b
8	If there is any conflict between the requirements in these building codes versus those in DOE-STD-1020-2016, are the more conservative design criteria being used?	DOE O 420.1C, Attachment 2, Chapter IV, 3.b
9	Does the design address • potential damage to and failure of SSCs resulting from both direct and indirect NPH events? • common cause/effect and interactions resulting from failures of other SSCs? • compliance with seismic requirements contained in DOE-STD-1020-2016?	DOE O 420.1C, Attachment 2, Chapter IV, 3.c
10	Does the mechanical design address the additional NPH requirements contained in Attachment A, LOI Set 3: Natural Phenomena Hazards and Structural Engineering, of this Engineering and Design Standard Review Plan?	DOE O 420.1C Ch IV
11	Have the facility designers identified the complete set of codes and standards necessary to meet the facility general design criteria, including those listed in DOE O 420.1C for mechanical and process equipment, ventilation, and mechanical handling equipment?	• DOE O 420.1C, Attachment 3, Section 3b, Tables 2, 3 and 4 • DOE G 420.1-1A, Section 5.4
12	Are the following DOE general requirements being implemented for the design, purchase, inspection, and testing of the HEPA filters? • 100 percent quality assurance testing of HEPA filters is required at the DOE Filter Test Facility (FTF). • HEPA filters shall be manufactured and qualified per ASME AG-1, Sections FC or FK, as applicable, and Sections 5, and 6.1 of DOE-STD-3020-2015 , unless otherwise noted. • All HEPA filters shall be production tested by the manufacturer per ASME AG-1, FC-5000 or FK-5000, as applicable.	DOE-STD-3020-2015, Section 4
13	During facility design, are there provisions to ensure that prior to their use, all HEPA filters that perform a safety function in accident situations, or are designated as important to safety, and all HEPA filters necessary for habitability systems, can meet the following criteria and are delivered to the FTF for quality assurance testing?	DOE-STD-3020-2015, Section 4

	Set 6: Mechanical Design Lines of Inquiry (LOIs)	Reference
	• For all other applications where HEPA filters are used in confinement ventilation systems for radioactive airborne particulate, develop and document an independent tailored filter QA testing program that achieves a high degree of fitness for service.	
14	During facility design, are there provisions to ensure that HEPA filters are being tested by the manufacturer and, in addition, that HEPA filters identified to be tested by the Filter Test Facility (FTF), are tested to the following criteria? • Penetration at 100% of manufacturer rated airflow • Penetration at 20% of manufacturer rated airflow for filters rated at 125 ACFM and greater • Airflow resistance at rated airflow as specified in Section 5.2.2 of DOE-STD-3020-2015	DOE-STD-3020-2015, Section 4
15	Does the facility design ensure that only the filters manufactured under a Quality Assurance Program, which has been evaluated with documented evidence of compliance to the requirements of DOE O 414.1D and ASME NQA-1, are to be used/installed at the facility?	DOE-STD-3020-2015, Section 6
16	Are there any provisions in the design process for requalification when any change is made to the design or construction or composition of construction materials that could affect filter performance?	DOE-STD-3020-2015, Section 6
17	Are the filter containers designed so that • they can be opened and the filter removed without damage to the container or the filter? • the container can be reused for shipment to alternate destinations?	DOE-STD-3020-2015, Section 7
18	Does the design of the piping systems document the selection of appropriate materials to allow for corrosion/erosion over the service life of the systems with consideration of the forces and conditions under which the systems will be performing?	Best Engineering Practice (BEP) as captured in DOE-HDBK-1132-99 [19], Part II, Section 3.1
19	Does the design process ensure that piping systems that perform safety-related functions are to be designed and fabricated to more rigorous standards than other fluid service piping? Note: In accordance with ASME B31.3, Process Piping, Category M Fluid Service may be designated for design, material, and component selection, fabrication and erection, and examination and inspection of these systems.	BEP as captured in DOE-HDBK-1132-99, Section 3.1
20	Does the design process ensure that piping systems that handle radioactive fluids, regardless of design pressures and temperatures, are categorized as Normal Fluid Service, at a minimum, in accordance with ASME B31.3 for design, material, and component selection, fabrication and erection, and examination and inspection?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
21	Does the design ensure that combined fire-protection and potable-water service or combined-process water and potable water systems are avoided to the extent practicable?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
22	Does the design ensure that backflow preventers and vacuum breakers are used, as appropriate?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
23	Does the design of supports for piping in compressible flow service consider the weight of the line filled with water for hydrostatic testing?	BEP as captured in DOE-HDBK-1132-99, Section 3.1

[19] This DOE *Design Considerations Handbook* was reaffirmed in 2014. Part II of the Handbook describes good practices and design principles that should be considered in specific design disciplines, including mechanical systems. These Best Engineering Practices (BEPs) are based on specific experiences in the design of nuclear facilities by design engineers with related experience.

	Set 6: Mechanical Design Lines of Inquiry (LOIs)	Reference
24	Does the design provide suitable flexibility at building interfaces to protect against differential settlement or seismic activity?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
25	Are components that create large pressure drops, such as valves and orifices, designed to minimize the effects of cavitation and flashing?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
26	Does the initial design conservatively estimate the piping load on equipment nozzles, such as vessels, heat exchanges, and pumps?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
27	Does the design ensure that the mid-span deflection due to dead-weight loading is limited to no more than 1/8 inch for lines that are required to drain, and to no more than 1/2 inch for lines that are not required to drain?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
28	Does the design for buried pipe provide a trench of sufficient width and depth to provide necessary bedding and cover, depending on traffic volume to facilitate joining, trapping, and future maintenance concerns?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
29	Does the design analysis for buried pipe consider soil, surface, internal pressure, thermal growth, soil settlement, water hammer, and seismic loads, as applicable?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
30	Does the design ensure that underground piping is buried beneath the frost line and has heat tracing/insulation to prevent freezing?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
31	Does the design ensure that • primary and secondary piping are supported and anchored? • supports are adequate to carry the weight of the lines and maintain proper alignment?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
32	Does the design ensure that pipe guides and anchors are provided to • keep pipes in accurate alignment? • direct the expansion movement? • prevent buckling, swaying, and undue strain?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
33	Does the design ensure that steam lines • slope at least 1/8 inch per foot in the direction of steam flow? • have adequate provisions for condensate considerations?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
34	Does the design ensure that each low point has a steam trap and free blow with drainage provisions to a lower elevation?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
35	Does the design ensure that drip legs include a steam trap and blow-down drains?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
36	Does the design include provisions to drain condensate from the upstream side of isolation valves?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
37	Does the design ensure that stream traps provide adequate capacity to • accommodate condensation loads during warm-up as well as during normal operation? • compensate for line size, length, and insulation type and thickness?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
38	Does the design ensure that aramid-fiber gasket material is used in any steam or condensate service?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
39	Does the design provide protection of the piping systems for damage caused by severe hydraulic transients?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
40	Does the design include use of vacuum-breaker valves (or check valves, as appropriate) in situations where water-column separation can occur?	BEP as captured in DOE-HDBK-1132-99, Section 3.1
41	Does the design include the use of purge gases and processes, as appropriate, to ensure that flammable/explosive concentrations of gases are not achieved in piping and vessel process systems?	BEP as captured in DOE-HDBK-1132-99, Section 3.2

	Set 6: Mechanical Design Lines of Inquiry (LOIs)	Reference
42	Does the design ensure the appropriate use of positive-displacement pumps?	BEP as captured in DOE-HDBK-1132-99, Section 3.3
43	Does the design ensure that gate valves are not used for throttling?	BEP as captured in DOE-HDBK-1132-99, Section 3.4
44	Does the design ensure that globe valves are used primarily for throttling service only, unless system flow reverses, and the globe valve serves as a stop valve?	BEP as captured in DOE-HDBK-1132-99, Section 3.4
45	Does the design ensure that simple check valves without external actuation are never used as stop valves, but instead are used as flow-reversal preventers?	BEP as captured in DOE-HDBK-1132-99, Section 3.4
46	Does the design use butterfly valves for stop valves or for throttling purposes in water systems?	BEP as captured in DOE-HDBK-1132-99, Section 3.4
47	Does the design use ball valves for bubble-tight stop valves in relatively clean fluid services?	BEP as captured in DOE-HDBK-1132-99, Section 3.4
48	Does the design use plug-and-diaphragm valves for stop valves, as appropriate?	BEP as captured in DOE-HDBK-1132-99, Section 3.4

LOI Set 7: Electrical Design

	Set 7: Electrical Design Lines of Inquiry (LOIs)	Reference
1	Are active safety-class electrical systems designed to preclude single-point failure? Note: IEEE-Std-379-2000, IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems, provides a definition of single failure criterion. ANS 58.9-2002 (R 2009), Single Failure Criteria for Light Water Reactor Safety-Related Fluid Systems, provides additional guidance for single-failure criteria for mechanical systems.	DOE O 420.1C, Chg 1 [20], Attachment 2, Chapter I, Section 3.b.(7)
2	Are the electrical codes and standards, as specified in DOE O 420.1C, used for the design? If not, was there DOE approval as required by 10 CFR 830, Subpart B?	• DOE O 420.1C, Chg 1, Section 5.4.14 • DOE O 420.1C, Chg 1, Attachment 3, Section 3.b, tables of codes and standards
3	Are safety-class equipment and safety-significant electrical equipment designed to meet environmental qualifications?	DOE G 420.1-1A [21], Section 5.4.14
4	Does the electrical design consider the following factors, as appropriate? • The number of required operating personnel • The number and types of processes to be operated • Duties of operating personnel • Control panel and consoles arrangement • Operator man–machine interface • Instrument equipment functions • Testing considerations • Maintenance considerations • Aesthetics • Lighting methods and intensities • Communications facilities • Control-center location relative to the rest of the plant • Control-center access and egress pathways • Security and safety considerations • Office and utility-room requirements • Computer room • Software engineering area • Ambient-noise levels and abatement devices	Best Engineering Practice [22] (BEP)

[20] DOE O 420.1C, Chg 1, February 27, 2015, establishes facility and programmatic safety requirements for the DOE, including the NNSA, for (1) nuclear safety design criteria; (2) fire protection; (3) criticality safety; (4) natural phenomena hazards (NPH) mitigation; and the (5) Cognizant system engineer (CSE) program.

[21] This DOE guide, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

[22] The Best Engineering Practices are described in DOE-HDBK-1132-99, *Design Considerations*, which was developed in 1999 and reaffirmed in 2014. The handbook contains good design practices based on lessons learned from various design, construction, startup, and operations experiences.

	Set 7: Electrical Design Lines of Inquiry (LOIs)	Reference
	• HVAC requirements: ambient temperature, air quality, and humidity • Fire-protection requirements • Wiring methods and requirements (including fiber optics) • Static-electricity discharge requirements • Grounding requirements • A storage and reference area for essential documents • Electromagnetic compatibility • Reliability • Power requirements • Human factors/ergonomics • The need for uninterruptible power supplies • The need for DC electrical sources	
5	Does the design use standard off-the-shelf electrical materials and equipment used on installations only if they have been tested and labeled by a nationally recognized testing laboratory (an international standards organization or recognized testing agency)?	BEP
6	Has onsite acceptance testing been performed on major electrical components and systems, as appropriate?	BEP
7	• Is the use of electrical tubing avoided in areas where the tubing may be subject to severe damage? • Is PVC used for conduits encased in concrete duct lines?	BEP
8	Is flexible conduit used for conduit connections to equipment subject to vibrations?	BEP
9	Are outdoor installations appropriate for their application?	BEP
10	Is aluminum conduit used in atmospheres where steel is unsuitable?	BEP
11	• Are steel conduits used to route power cables to motors supplied from variable-frequency controllers to minimize noise to and from adjacent circuits? • Do variable-frequency controllers include electrical filters?	BEP
12	Are all receptacles with their power source labeled, including uninterrupted power supply critical circuits?	BEP
13	Do electrical penetrations through a fire barrier have an approved fire-barrier seal?	BEP
14	Are penetrations through confinements designed to minimize leakage?	BEP
15	Does the use of cable trays consider the following guidelines? • Use cable trays for large, multiple-cable applications in both interior and exterior locations. • Arrange cable tray runs in stacks by descending voltage levels, with the highest voltage at the top. • Consider the minimum bending radius of all medium-voltage cables to be routed through the tray system during the selection of the cable-tray bending radius (horizontal and vertical). • Consider the location of monorails, equipment removal spaces, and floor hatches in the layout design so that raceways do not interfere with equipment removal. • Use drip shields where piping lines cross over cable trays. • Wherever possible, locate cable trays away from heat sources such as steam lines and hot process piping. When locating cable trays away from heat sources is not possible, analyses may be required to determine whether high-temperature cable and/or heat shielding is required. Cable trays should also be located away from potential fire hazards, such as lube oil and fuel oil storage tanks.	BEP

	Set 7: Electrical Design Lines of Inquiry (LOIs)	Reference
	• Raceways that require multiple cable trays may be installed in a vertical or horizontal (side-by-side) arrangement, as required by the facility configuration.	
16	For design/modification of existing facilities, are the following guidelines considered when using existing raceways? • Additional new cables should not exceed the allowable raceway fill guidelines of IEEE-1185. • When power cables are added, evaluate the current capacity of all cables(existing and new) within the raceway. • The minimum bending radius of new cables should not be violated when pulled through existing raceways. • Evaluate the conduit and tray support system to stay within design loads when new cables are added. • When pulling cables in existing trays, refer to IEEE-1185 for guidance for avoiding damage to cables.	BEP
17	Are demand and diversity factors considered in calculating service capacity, substation, and feeder loads?	BEP
18	Does the design properly address loads that require a high degree of service reliability?	BEP
19	Does the design ensure that standby or emergency power systems are used to support systems or equipment components whose operating continuity is determined to be vital by the design authority for protection of health, life, property, and safeguards and security systems?	BEP
20	Does the design of control centers/control rooms address the following factors? • Number of required operating personnel • Number and types of processes to be operated • Duties of operating personnel • Control panel and consoles arrangement • Operator man–machine interface • Instrument equipment functions • Testing considerations • Maintenance considerations • Aesthetics • Lighting methods and intensities • Communications facilities • Control-center location relative to the rest of the plant • Control-center access and egress pathways • Security and safety considerations • Office and utility-room requirements • Computer room • Software engineering area • Ambient noise levels and abatement devices • HVAC requirements: ambient temperature, air quality, and humidity • Fire protection requirements • Wiring methods and requirements (including fiber optics) • Static-electricity discharge requirements • Grounding requirements	BEP

	Set 7: Electrical Design Lines of Inquiry (LOIs)	Reference
	• Essential documents storage and reference area • Electromagnetic compatibility • Human factors/ergonomics (see IEEE-1023, ISA RP60.3) • Reliability • Power requirements	
21	Does the design provide a systematic approach for identifying, verifying, prioritizing, and documenting the requirements for process alarms?	BEP
22	Does the design provide capability of alarm pattern recognition and suppression of alarms by group, status, function, or mode?	BEP
23	Does the design provide an alarm only when the operator is required to take action to avert an abnormal event?	BEP
24	Does the design provide report alarms hierarchically to the operator to prevent a single event from causing a cascading of alarms?	BEP
25	Does the design provide capability to advise the operator of the appropriate response to an alarm or to trigger an automatic response?	BEP
26	Does the design address the criteria to minimize electrical noise in wiring?	BEP
27	Does the design address the criteria for lightning protection of instruments?	BEP
28	Does the design address the criteria for analyzers?	BEP
29	Does the design address the criteria for solenoid valves?	BEP
30	Does the design address the general criteria for instrument installation?	BEP
31	Does the design address the instrument location criteria?	BEP
32	Does the design address the pressure instrument criteria?	BEP
33	Does the design ensure that temperature instruments are installed in a thermowell to allow removal without process disturbance?	BEP
34	Does the design provide adequate space to allow removal of thermocouples, resistance temperature detectors, thermal bulbs, or indicators?	BEP
35	Does the design address the criteria of flow instruments?	BEP
36	Does the design address the criteria of liquid-level instruments?	BEP
37	Does the design of instrument systems ensure that they do not freeze under adverse weather conditions and when handling high-freeze-point materials?	BEP

LOI Set 8: Instrumentation and Control Design

	Set 8: Instrumentation and Control Design Lines of Inquiry (LOIs)	Reference
1	Are the codes and standards, as specified in DOE O 420.1C, used for the design of instrumentation, control, and alarm systems? If not, was there DOE approval as required by 10 CFR 830, Subpart B?	• DOE O 420.1C, Chg 1 [23], Section 5.4.14 • DOE O 420.1C, Chg 1, Attachment 3, Section 3.b, Table 7
2	Does the design of safety-class (SC) instrumentation and control systems incorporate sufficient independence, redundancy, diversity, and separation to ensure that all safety-related functions associated with such equipment can be performed? Note: DOE-STD-1195-2011 provides an acceptable method for achieving high reliability of safety-significant safety instrumented systems.	DOE O 420.1C, Chg 1, Attachment 3, Section 3.b, Table 7
3	Does the design of SC and safety-significant (SS) instrumentation, controls, and alarms consider whether failure of non-safety equipment will not prevent the former from performing their safety functions?	DOE G 420.1-1A [24], Section 5.4.15
4	Does the design of SC and SS instrumentation, controls, and alarms consider accessibility for inspection, maintenance, calibration, repair, or replacement?	DOE G 420.1-1A, Section 5.4.15
5	Does the design of SC and SS instrumentation, controls, and alarms provide the operators sufficient time, information, and control capabilities to perform the following safety functions? • Readily determine the status of critical facility parameters to ensure compliance with the limits specified in the technical safety requirements. • Initiate manual safety function. • Determine the status of safety systems required to ensure proper mitigation of the consequences of postulated accident conditions and/or to safely shut down the facility.	DOE G 420.1-1A, Section 5.4.15
6	Is ANSI/ISA 84.00.01-2004 [25] being used for the design of SS safety instrumented systems (SISs)?	• DOE-STD-1195-2011 [26], Section 2.1

[23] DOE O 420.1C, Chg 1, February 27, 2015, establishes facility and programmatic safety requirements for the DOE, including the NNSA, for (1) nuclear-safety design criteria; (2) fire protection; (3) criticality safety; (4) natural phenomena hazards (NPH) mitigation; and the (5) Cognizant system engineer (CSE) program.

[24] This DOE guide, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

[25] ANSI/ISA 84.00.01-2004, Part 1, design methodology should not be used for instrumented systems in the following applications because they are more appropriately covered by other industry standards, such as National Fire Protection Association (NFPA) standards and American Nuclear Society 8.3, Criticality Accident Alarm Systems. Users should judge whether the SS SISs are more appropriately covered by any other industry standards. DOE G 420.1-1 identifies the standards that would be applied to systems such as (1) Evacuation alarms (for example, nuclear-incident monitors, fire alarms, and public-address systems); (2) fire protection/detection systems (covered by NFPA standards); and (3) Support systems (for example, electrical power systems, instrument air systems).

[26] DOE-STD-1195-2011, *Design of Safety Significant Safety Instrumented Systems Used at DOE Non-Reactor Nuclear Facilities,* provides requirements and guidance for the design, procurement, installation, testing, maintenance, operation, and quality assurance of safety instrumented systems (SIS) that may be used at DOE nonreactor nuclear facilities for safety significant (SS) functions.

	Set 8: Instrumentation and Control Design Lines of Inquiry (LOIs)	Reference
	Note: The standards are listed in DOE G 420.1-1 for SC instrumentation and control systems. However, the listed standards include some design requirements that are unwarranted for the design of SS SISs used in DOE nonreactor nuclear facilities. For example, nuclear-power industry standards calls for single-failure-proof designs, when other options to achieve adequate reliability might be more appropriate and more cost-effective.	• DOE-STD-1195-2011, Appendix C
7	Are the safety-software quality-assurance requirements and guidance of DOE 414.1D and DOE G 414.1-4 being implemented to meet the objectives of ISA 84.00.01-2004, Part 1, Clause 12, Requirements for Application Software, Including Selection Criteria for Utility Software?	• DOE-STD-1195-2011, Section 2.2 • DOE-STD-1195-2011, Appendix F
8	Is there justification provided for commercial-grade dedication (CGD) used to approve the selection of components and subsystems in an SIS in lieu of the ANSI/ISA 84.00.01-2004, Part 1, Clause 11.5, methodology of acceptance by qualification to IEC 61508, Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-Related Systems and/or “prior use”?	DOE-STD-1195-2011, Section 2.3
9	Is ASME Nuclear Quality Assurance (NQA)-1, Quality Assurance Requirements for Nuclear Facility Applications, used to establish the CGD process? Note: The goal of CGD is to provide a reasonable assurance that an item procured will perform its intended safety function, as specified by design requirements.	DOE-STD-1195-2011, Section 2.3
10	Are the following critical characteristics for CGD being addressed when assessing the acceptability of an SIS that utilizes software for meeting the design attributes? • Failure rate of an item, such as: o unsafe/dangerous failure rate (detected and undetected) o safe failure rate (spurious trip rate) • Safe-failure state, and safe recovery • Environmental design constraints • Software critical characteristics—for example, build date, release name, part or catalog number, and traceability matrix • Diagnostic coverage • Response time • Accuracy • Isolation capability of component/system from non-safety interfaces (that is, communication inputs and outputs) • Unused and unintended or prohibited functions • Supplier catalog and part number • Supplier technical manual and product specification • Conformance to national codes and standards	DOE-STD-1195-2011, Section 2.3
11	Are the requirements of ANSI/ISA 67.04.01, Set points for Nuclear Safety-Related Instrumentation, being implemented for SS SIS set point development, including indications and alarms?	DOE-STD-1195-2011, Section 2.4
12	Are power sources (that is, electric power or instrument air) provided with backup power sufficient to fulfill the requirements of the SIS safety function, except in cases where the design is fail-safe on loss of power?	DOE-STD-1195-2011, Section 2.5
13	Are the processes for performing life-cycle management for SIS been defined in the design process, including identifying the organization(s) responsible for implementing them?	• DOE-STD-1195-2011, Section 2.6 • DOE-STD-1195-2011, Appendix C, Section A.3

	Set 8: Instrumentation and Control Design Lines of Inquiry (LOIs)	Reference
	Note: A key aspect of the implementation of ANSI/ISA 84.00.01-2004 is effective control over each stage of the SIS life cycle to ensure proper initial design, proper installation, effective operation and maintenance, and configuration control. The life-cycle stages can be fulfilled by conformance to the ANSI/ISA 84.00.01-2004 requirements or by conformance to DOE orders, manuals, standards, and guides that provide equivalent processes and methods for the life-cycle stages of the safety instrumented functions.	
14	Does the design of SIS take into account human–machine interfaces and their limitations, and does it follow good human-factors engineering practices (HFE) as required by ANSI/ISA 84.00.01-2004, Part I, Clause 11.2.6? Note: HFE involves diverse areas—for example, information display, user-system interaction, alarm management, operator response, control room design, and system maintainability—which affect all aspects of a system's development and modification.	• DOE-STD-1195-2011, Section 2.7 • DOE-STD-1195-2011, Appendix G
15	Is an HFE Plan developed for the SS SIS, which defines the required participants and human factors activities, including the documentation, review, and approval of each activity?	• DOE-STD-1195-2011, Section 2.7 • DOE-STD-1195-2011, Appendix G
16	Are the details of the HFE Plan developed in accordance with the guidance provided in Section 5.4.9 of DOE G 420.1-1A?	• DOE-STD-1195-2011, Section 2.7 • DOE-STD-1195-2011, Appendix G
17	Does the HFE process follow the applicable requirements of DOE O 414.1D for software and hardware configuration controls?	• DOE-STD-1195-2011, Section 2.7 • DOE-STD-1195-2011, Appendix G
18	Are the SS SISs secured from electronic vulnerabilities, including unauthorized and/or inappropriate access that may harm system integrity and safety? Note: DOE-STD-1195-2011 does not provide details of security requirements for SIS design. ANSI/ISA 84.00.01-2004, Clause 11.7.2.2, provides some basic access-security protection measures. Users should consult applicable DOE 470 and 205 series directives and other industry standards to ensure that the design meets the security requirements.	DOE-STD-1195-2011, Section 2.8
19	Does the SS SIS design development process address the potential security vulnerabilities in each phase of the system life cycle? Are the requirements commensurate with the risk and magnitude of harm resulting from unauthorized and inappropriate access, use, disclosure, disruption, or destruction of the system?	DOE-STD-1195-2011, Section 2.8
20	Has a method been established in the design process for determining the appropriate safety integrity level (SIL) for SS safety instrumented function? Note: The SIL provides design input to an SS SIS that is credited with reducing the risk of a hazardous event by itself or in combination with other features to an acceptable level, as defined in the safety basis documentation. The SIL determination methodology defined in DOE-STD-1195-2011 shall not be used as an input or requirement to hazard/safety analysis, classification of Structures, Systems, and Components (SSC) as safety class (SC) or SS, or crediting of SSCs, specific administrative controls (SAC), or administrative controls (AC) to prevent or mitigate hazardous conditions.	DOE-STD-1195-2011, Appendix A and Appendix D
21	Have the SIL calculations been verified as required in Section 11.9.1 of ANSI/ISA 84.00.01-2004, Functional Safety: Safety Instrumented Systems for the Process Industry Sector?	DOE-STD-1195-2011, Appendix C and Appendix D
22	Has the average probability of failure on demand of the SS SISs been verified to determine if they meet their SIL?	DOE-STD-1195-2011, Appendix E

LOI Set 9: Radiation Protection

	Set 9: Radiation Protection Lines of Inquiry (LOIs)	Reference
1	During the facility design process, have design measures been taken to maintain radiation exposure in controlled areas As Low As Reasonably Achievable (ALARA) through engineered and administrative controls?	10 CFR 835, *Occupational Radiation Protection, Subpart K, Design and Control*, Section 10 CFR 835.1001, *Design and Control*
2	Are the physical design features (for example, confinement, ventilation, remote handling, and shielding) the primary methods used?	10 CFR 835, *Occupational Radiation Protection*, Subpart K, Design and Control, Section 10 CFR 835.1001, *Design and Control*
3	Are the administrative controls (ACs) defined in the design process employed only as supplemental methods to control radiation exposure? Note: For specific activities where use of physical design features is demonstrated to be impractical, ACs shall be used to maintain radiation exposures ALARA.	10 CFR 835, *Occupational Radiation Protection*, Subpart K, Design and Control, Section 10 CFR 835.1001, *Design and Control*
4	Are optimization methods used to ensure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls?	• 10 CFR 835.1002(a) • DOE-STD-1098-2008, *Radiological Control*, Section 381 • DOE-HDBK-1132-99, Design Considerations, Section 1.3.2
5	Is the design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2,000 hours per year) to maintain exposure levels below an average of 0.5 millirem (5 µSv) per hour and as far below this average as is reasonably achievable?	• 10 CFR 835.1002(b) • DOE-STD-1098-2008, Section 381
6	Are the design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above ALARA less than 20 percent of the applicable standards in 10 CFR 835, §835.202?	• 10 CFR 835.1002(b) • DOE-STD-1098-2008, Section 381
7	Are ALARA principles being applied when designing confinement and ventilation systems to limit airborne contamination levels?"	• 10 CFR 835.1002(c) • DOE-HDBK-1132-99, Section 1.3.3 • DOE-STD-1098-2008, Section 381
8	Do the design or modification of a facility and the selection of materials include features that facilitate operations, maintenance, decontamination, and decommissioning?	• 10 CFR 835.1002(d) • DOE-HDBK-1132-99, Section 2.12.1 • DOE-STD-1098, Section 381
9	• Does the facility design accommodate the requirements for safeguards and security, emergency egress, and area access control for worker protection? • If these requirements appear to conflict, does life safety take precedence? • Are specific requirements for access control implemented as specified by 10 CFR 835 for radiological hazards?	• CFR 835.501(e) • DOE G 420.1-1A, Section 5.4.4
10	Do the radiation protection and contamination control design considerations consider the type and level of hazards determined, the attendant degree of risk established, and the possibility of cross-contamination?	DOE G 420.1-1A, Section 5.4.3

	Set 9: Radiation Protection Lines of Inquiry (LOIs)	Reference
11	Are work areas with compatible contaminants designed to be located together to simplify design criteria related to air supply and exhaust, waste disposal, decontamination, and cross-contamination?	DOE G 420.1-1A, Section 5.4.3
12	Are radioactive and hazardous-material contamination control requirements considered in the design to minimize the potential for contamination spread?	DOE G 420.1-1A, Section 5.4.3
13	Are office areas designed to locate in common-use facilities (for example, data computation and processing and word processing) and away from process areas to minimize worker risks of exposure to radioactive and/or hazardous materials?	DOE G 420.1-1A, Section 5.4.3
14	Does the building layout provide protection from the hazards associated with the handling, processing, and storing of radioactive and/or hazardous materials?	DOE G 420.1-1A, Section 5.4.3
15	Has additional space been provided for temporary or additional shielding in the event that radiation levels are higher than anticipated?	DOE G 420.1-1A, Section 5.4.3
16	Do the arrangement and location of hazardous process equipment and its maintenance provisions provide appropriate protective and safety measures, as applicable?	DOE G 420.1-1A, Section 5.4.3
17	Does the building design accommodate a prompt return to safe conditions in emergencies and allow ready access for, and protection of, workers in areas where manual corrective actions are required and in areas that contain radiation-monitoring equipment readouts?	DOE G 420.1-1A, Section 5.4.3
18	Does the facility layout provide specific control and isolation, if possible, of quantities of flammable, toxic, and explosive gases, chemicals, and other hazardous materials admitted to the facility?	DOE G 420.1-1A, Section 5.4.3
19	Has the integration of security considerations with radiation protection considerations been considered in the building layout and structural design of the facility?	DOE G 420.1-1A, Section 5.4.3
20	Are specific criteria applied for the following radiation-protection design areas, as required by 10 CFR 835? • Radiation monitoring and entry and exit control systems • Posting and labeling of radioactive materials and spaces • Nuclear accident dosimetry • ALARA applications	DOE G 420.1-1A, Section 5.4.3
21	For the design of physical layout and details of proven radiological equipment for plutonium facilities, are the Good Practices contained in DOE-STD-1128-2013 [27] used?	DOE G 420.1-1A, Section 5.4.3
22	If shielding is part of the design, is it designed to at least the same level of natural phenomenon qualification as the facility structure? Note: Shielding design guidance is contained in ANSI/ANS 6.4.2-2006, *Specification for Radiation Shielding Materials*.	DOE G 420.1-1A, Section 5.4.3
23	Is shielding designed to limit the total external dose during normal operations to the annual exposure limit values, as specified in 10 CFR 835?	DOE G 420.1-1A, Section 5.4.3
24	Are occupied operating areas for normal operating conditions designed not to exceed the airborne concentration limits of 10 CFR 835?	DOE G 420.1-1A, Section 5.4.3
25	Are devices to monitor individual exposures to external radiation and to warn personnel of radioactive contamination used in accordance with 10 CFR 835?	• DOE G 420.1-1A, Section 5.4.3 • DOE-HDBK-1132-99, Section 1.3.4

[27] This Technical Standard, revised in 2013, does not contain any new requirements. Its purpose is to provide information on good practices, update existing reference material, and discuss practical lessons learned relevant to the safe handling of plutonium.

	Set 9: Radiation Protection Lines of Inquiry (LOIs)	Reference
	• Is air-sampling equipment designed to be located in strategic locations to detect and evaluate airborne-contaminant conditions at work locations? • Are continuous air monitors with preset alarms provided to give early warning of significant releases of radioactive materials? • Do air monitoring and warning systems comply with the requirements of 10 CFR 835?	
26	Does the design of the breathing-air supply systems, if needed, comply with the requirements of 29 CFR 1910?	• 29 CFR 1910, *Occupational Safety and Health Standards*, Section 134, *Respiratory Protection* • DOE G 420.1-1A, Section 5.4.3
27	Are alarms considered in the design process for the loss of ventilation or differential pressure for the primary confinement systems (glove boxes or hoods) and secondary confinement systems (rooms)?	DOE G 420.1-1A, Section 5.4.3
28	Have change rooms for changing into and out of protective clothing been designed to ensure that clean clothing (personal clothing) and contaminated clothing (protective clothing) are segregated?	• DOE G 420.1-1A, Section 5.4.3 • DOE-HDBK-1132-99, 1.3.4
29	Are personnel decontamination facilities designed to be located close to areas that are potential sources of contamination?	• DOE G 420.1-1A, Section 5.4.3 • DOE-HDBK-1132-99, 1.3.4

LOI Set 10: Hazardous Materials

	Set 10: Hazardous Material Lines of Inquiry (LOIs)	Reference
1	During the design process, does the contractor have an adequate Process Safety Management System in place for highly hazardous material?	• 29 CFR 1926.64 • 29 CFR 1910.119 • 10 CFR 851.23(3)(7)
2	Does the design of engineered controls for hazardous material protection comply with requirements contained in the International Building Code, 10 CFR Part 851, and 29 CFR Part 1910, Subparts G, H, and Z?	• 29 CFR 1910 • 10 CFR 851.23(3) • DOE G 420.1-1A, Section 5.4.5
3	Does the design incorporate the ALARA approach, the elements to provide hazardous material exposure control, and facility protection instrumentation?	DOE-STD-1189-2016, Appendix E.14
4	Are prevention practices, such as substitution of less hazardous materials, part of the design strategy to reduce generation of hazardous waste?	DOE-STD-1189-2016, Appendix E.14
5	Have major hazardous materials typically associated with process requirements been identified and considered within the safety strategy?	DOE-STD-1189-2016, Appendix E.14
6	Has the process design identified and refined inventory or maximum anticipated quantities to structure, system, and component (SSC)?	DOE-STD-1189-2016, Appendix E.14
7	Have provisions for facility monitoring and protection instrumentation for worker protection been considered?	DOE-STD-1189-2016, Appendix E.14
8	Are work areas with compatible contaminants designed to be located together to simplify design criteria related to air supply and exhaust, waste disposal, decontamination, and cross-contamination?	DOE G 420.1-1A, Section 5.4.3
9	Are office areas designed to be located in common-use facilities (for example, data computation and processing and word processing) and away from process areas to minimize worker risks of exposure to hazardous material?	DOE G 420.1-1A, Section 5.4.3
10	Does the design of the building layout provide protection from the hazards associated with handling, processing, and storing of hazardous material as well as radioactive material?	DOE G 420.1-1A, Section 5.4.3
11	Do the arrangement and location of hazardous process equipment and its maintenance provisions provide appropriate protective and safety measures, as applicable?	DOE G 420.1-1A, Section 5.4.3
12	Does the building design accommodate prompt return to safe conditions in emergencies and allow ready access for, and protection of, workers in areas where manual corrective actions are required?	DOE G 420.1-1A, Section 5.4.3
13	Does the facility layout provide specific control and isolation, if possible, of quantities of flammable, toxic, and explosive gases, chemicals, and other hazardous materials admitted to the facility?	DOE G 420.1-1A, Section 5.4.3
14	Are alarms considered in the design process for the loss of ventilation or differential pressure for the primary confinement systems (glove boxes or hoods) and secondary confinement systems (rooms)?	DOE G 420.1-1A, Section 5.4.3
15	Does the design facilitate deactivation by incorporating facility features that aid in the removal of surplus chemical material; storage tank cleanout and maintenance; stabilization of contamination and process materials; and the removal of hazardous, mixed, and radioactive wastes?	• DOE G 420.1-1A, 5.4.1 • DOE-HDBK-1132-99, Section 2.12
16	Does the facility design incorporate measures to simplify decontamination of areas that may become contaminated with radioactive or hazardous materials?	• DOE G 420.1-1A, 5.4.1 • DOE-HDBK-1132-99, Section 2.12

	Set 10: Hazardous Material Lines of Inquiry (LOIs)	Reference
17	Are the design features to facilitate decommissioning consistent with the requirements of DOE O 435.1, *Radioactive Waste Management*?	DOE G 420.1-1A, Section 5.4.1
18	Are the following design principles considered to facilitate decommissioning? • Use of localized liquid-transfer systems • Minimizing of long runs of internally contaminated ductwork • Equipment that precludes the accumulation of radioactive and hazardous materials in relatively inaccessible areas, including curves and turns in piping and ductwork • Accessible, removable covers for inspection and cleanouts • Use of modular radiation shielding in lieu of, or in addition to, monolithic shielding walls • Provisions for flushing and/or cleaning contaminated, or potentially contaminated, piping systems • Provisions for suitable clearances to accommodate equipment removal and access for remote handling and safety surveillance equipment • Use of lifting lugs on large tanks and equipment • Piping systems that carry contaminated, or potentially contaminated, liquid should be free-draining via gravity	DOE G 420.1-1A, Section 5.4.1
19	Does the design ensure that respirators are not required for normal operating conditions or routine maintenance activities except as a precautionary measure?	DOE G 420.1-1A, Section 5.4.5
20	Do ventilation systems for hazardous-material protection either use exhaust hoods to control concentrations of hazardous materials from discrete sources, or control the number of air changes per hour for an entire room or bay?	DOE G 420.1-1A, Section 5.4.5
21	Does the design minimize hazardous-material exposure to personnel, both external and internal, and provide adequate monitoring and notification capabilities to inform workers of unsafe conditions?	DOE G 420.1-1A, Section 5.4.5
22	Does the design provide hazardous-material protection through remote handling, area and equipment layout, spill-control features, confinement, and ventilation?	DOE G 420.1-1A, Section 5.4.5
23	Does the design preclude occupied spaces where low oxygen content or air displacement may occur or where reactive, combustible, flammable, or explosive gas, vapor, or liquid accumulation might occur?	DOE G 420.1-1A, Section 5.4.5
24	Does the design include safety controls and features that consider contaminant chemical forms and minimize the potential for inhalation and contact under all conditions?	DOE G 420.1-1A, Section 5.4.5
25	Does the design include directed ventilation flow paths to move contaminants away from worker breathing zones?	DOE G 420.1-1A, Section 5.4.5
26	Does the design ensure that ventilation flow will cascade from clean areas to contaminated areas to preclude contamination spread?	DOE G 420.1-1A, Section 5.4.5
27	Does the design provide for uniform distribution of incoming air and/or air mixing equipment to ensure that no pockets of stagnant air exist in areas where workers are present?	DOE G 420.1-1A, Section 5.4.5
28	Is chemical hazard evaluation part of the integrated safety-in-design strategy for facility design?	• DOE-STD-1189-2016 • DOE-STD-3009-2014 [28]
29	As part of the safety-in-design (SID) process, do chemicals that screened out in this manner still need to be considered for their possible impact on radiological or	DOE-STD-3009-2014, Section 3.1.3

[28] DOE-STD-3009 was revised in 2014 and it included the chemical hazard evaluation criteria contained in DOE-STD-1189-2008, which were deleted it is current revision.

	Set 10: Hazardous Material Lines of Inquiry (LOIs)	Reference
	other chemical accident initiation or progression, or for a potential adverse impact on safety systems?	
30	Are chemical properties such as reactivity, toxicity, and incompatibility with other chemicals included in the chemical hazard evaluation?	DOE-STD-3009-2014, Section 3.1.3
31	If a qualitative chemical-hazard evaluation was performed, are the chemical consequences compared with the threshold values in Table 1, Consequence Thresholds, of Section 3.1.3 of DOE-STD-3009-2014?	DOE-STD-3009-2014, Section 3.1.3
32	Is quantitative chemical hazard evaluation performed to determine impacts to colocated workers and the public if the chemical hazards have the potential to exceed the safety-significant (SS) control selection criteria stated in DOE-STD-3009-2014?	DOE-STD-3009-2014, Section 3.1.3
33	For the purpose of identifying SS structures, systems, and components (SSCs), is evaluation of colocated worker consequences and offsite chemical consequences performed as part of either the hazard analysis or the accident analysis?	DOE-STD-3009-2014, Section 3.2
34	If the unmitigated consequences of a release scenario exceed established chemical or radiological thresholds, are safety-class (SC) and/or SS controls established as part of the SID process?	DOE-STD-3009-2014, Section 3.2
35	For chemical dispersion analysis, if neither a radiological dispersion analysis nor a DOE “Toolbox code” is used, does the modeling protocol address the appropriateness of the model to the site-specific situation, including source term characterization?	DOE-STD-3009-2014, Section 3.2.4.3
36	Have the chemical consequence results been submitted to the appropriate DOE Safety Basis Approval Authority for approval prior to use as part of the design process?	DOE-STD-3009-2014, Section 3.2.4.3
37	Is SS designation of controls for protection of the public from chemical releases based on a peak-15-minute time-weighted average air concentration, measured at the receptor location, that exceeds Protective Action Criteria (PAC-2) (Acute Exposure Guideline Level (AEGL)-2, Emergency Response Planning Guideline (ERPG)-2, and/or Temporary Emergency Exposure Limit (TEEL)-2)? Note: DOE’s Protective Action Criteria are defined by Advanced Technologies and Laboratories International, Inc, in *Protective Action Criteria (PAC): Chemicals with AEGLs, ERPGs, & TEELs*, Rev 27, February 2012. That document is available at http://www.atlintl.com/DOE/teels/teel.html.	DOE-STD-3009-2014, Section 3.3.2
38	Is SS control designation made on the basis of the control’s contribution to: (1) defense-in-depth; (2) protection of the public from release of hazardous chemicals; (3) protection of colocated workers from hazardous chemicals and radioactive materials; and (4) protection of in-facility workers from fatality, serious injury, or significant radiological or chemical exposure?	DOE-STD-3009-2014, Section 3.3.2
39	Is SS designation for protection of colocated workers from chemical releases based on a peak-15-minute time-weighted average air concentration at the receptor location that exceeds PAC-3?	DOE-STD-3009-2014, Section 3.3.2
40	Are all hazardous materials being considered in the facility process design being addressed as part of the Comprehensive Emergency Management System?	DOE O 151.1D

LOI Set 11: Sustainability

	Set 11: Sustainability Lines of Inquiry (LOIs)	Reference
Critical Decision-1 Requirements and Guidance		
1	Prior to Critical Decision-1, have the following requirements been applied to the complete conceptual design? • Guiding Principles for Federal Leadership in High Performance and Sustainable Building provisions per EO 13693, Section 3(h) • Support for the Site or Strategic Sustainability Plan(s) per DOE O 436.1 and/or other sustainability considerations planned in the Conceptual Design Report, Acquisition Strategy, and/or PEP	• DOE O 413.3B, Chg 2 • DOE G 413.3-6A, Chg 1
2	Has the Federal Project Director (FPD) directed the project to integrate the high-performance sustainable building (HPSB) principles into key project documents, including the Conceptual Design Report, Project Execution Plan, and Acquisition Strategy?	DOE G 413.3-6A, Section 6A
3	• Are there Leadership in Energy and Environmental Design (LEED)-accredited professionals on the Federal Integrated Project Team? • Are there LEED accredited professionals on the contractor's project team?	DOE G 413.3-6A, Section 6A
4	Does the project use a sustainability assessment tool based on the LEED rating system to certify the project's conformance with the HPSB principles? Note: If no, justification needs to be provided for not using the LEED rating system.	DOE G 413.3-6A, Section 6A
5	Has the project prepared a Sustainable Design Report? Note: If no, does the Conceptual Design Report describe the sustainable features of the design?	DOE G 413.3-6A, Section 6A
6	Does the project follow the Whole Building Design concepts in implementing Executive Order 13423's sustainable building requirements and HPSB principles?	DOE G 413.3-6A, Section 5
7	If the decision is to exempt the project from all or some of the HPSB principles, has the exemption decision and rationale been documented in the Conceptual Design Report and the Acquisition Strategy?	DOE G 413.3-6A, Section 6A
8	Have the HPSB requirements been incorporated into the Contract?	DOE G 413.3-6A, Section 6A
9	Does the design of the new construction or major building renovations meet the U.S. Green Building Council's LEED Gold certification absent an approved waiver from the Project Management Executive?	• DOE O 413.3B, Attachment 1, *Contract Requirements Document*, Requirement 16 • DOE 436.1, *Departmental Sustainability*
Critical Decision-2 Requirements and Guidance		
10	Prior to Critical Decision-2, have the EO 13693 and DOE O 436.1 requirements been incorporated for the completions of preliminary and/or final design for nuclear facilities? Note: As required in DOE O 413.3B, Hazard Category 1, 2, and 3 nuclear facilities shall achieve at least 90% design completion prior to CD-2 approval.	• DOE O 413.3B, Chg 2 • DOE G 413.3-6A, Section 6B
11	For preliminary and final design, has the project decided which sustainable building features can be achieved, based on design tradeoffs between desired features, cost, safety, and environmental concerns?	DOE G 413.3-6A, Section 6B
12	Can the project achieve the intended LEED rating level?	DOE G 413.3-6A ,Section 6B
13	Is the documentation updated to support the LEED rating-level certification?	DOE G 413.3-6A, Section 6B

	Set 11: Sustainability Lines of Inquiry (LOIs)	Reference
14	Has the Sustainable Design Report been updated, or have the preliminary and final design reports been developed to include the discussion of the sustainable design features?	DOE G 413.3-6A, Section 6B
Critical Decision-3 Requirements and Guidance		
15	Prior to Critical Decision-3, have the EO 13693 and DOE O 436.1 requirements been incorporated for the completions of final design for non-nuclear facilities and less-than-Hazard Category 3 nuclear facilities? Note: For nuclear project, final design (90% completion) shall be completed in Critical Decision-2 as required in the current DOE O 413.3B.	• DOE O 413.3B • DOE G 413.3-6A, Section 6C
16	Have the final HPSB design principles been incorporated into the final design and the External Independent Review?	DOE G 413.3-6A, Section 6C
17	Has the FPD requested an External Independent Review to review the sustainable building features?	DOE G 413.3-6A, Section 6C
18	Has the Sustainable Design Report been updated, or has the Final Design Report been developed to include the discussion of the sustainable design features?	DOE G 413.3-6A, Section 6C

LOI Set 12: Human Factors

	Set 12: Human Factors Lines of Inquiry (LOIs)	Reference
1	Is human-factors design being considered in, but not limited to, the following design areas? • Equipment labeling • Workplace environment (temperature and humidity, lighting, noise, vibration, and aesthetics) • Human dimensions • Operating panels and controls • Component arrangement • Warning and annunciator systems • Communication systems	DOE G 420.1-1A [29], Section 5.4.9
2	Does the human-factors design consider the criteria found in • Nuclear Regulatory Guide (NUREG) 0700, *Human-System Interface Design Review Guidelines*? • Department of Defense MIL-STD-1472D, *Department of Defense Design Criteria Standard: Human Engineering*? • Institute of Electrical and Electronics Engineers (IEEE) 1023-2004, *IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and other Nuclear Facilities*?	DOE G 420.1-1A, Section 5.4.9
3	Was the application of human factors for the design established as a design philosophy early in the conceptual design phase?	DOE-STD-1189-2016, Appendix E.11
4	Through the design phases, did this philosophy evolve to consider standard human-interface issues?	DOE-STD-1189-2016, Appendix E.11
5	Does the human-factors design include operator input and reviews by maintenance and test personnel to ensure access for maintainability and testability?	DOE-STD-1189-2016, Appendix E.11
6	During safety bases development at the design phases, are the following human factors considered? • Designing facilities, systems, equipment, and tools so they are sensitive to the capabilities, limitations, and needs of humans • Ensuring that an operator can perform the items required under a SAC in the timeframes assumed in the safety analysis • Human reliability analyses that quantify the contribution of human error to the facility risk	DOE-STD-1189-2016, Appendix E.11
7	Are these human factors applied to the design in • the layout and design of SSCs for operation, construction, maintenance, and testing or surveillance? • the evaluation of failure probability of human relied upon actions?	DOE-STD-1189-2016, Appendix E.11

[29] DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

	Set 12: Human Factors Lines of Inquiry (LOIs)	Reference
8	Does the design of SIS comply with the requirements of ANSI/ISA 84.00.01-2004, Part I, Clause 11.2.6? Note: The ANSI standard requires the design to take into account human–machine interfaces and their limitations and to follow good human-factors engineering (HFE) practices.	DOE-STD-1195-2011 [30], Section 2.7
9	Was an HFE Plan developed as part of the design process? Note: The HFE should be developed in accordance with DOE G 420.1-1A and guided or supplemented by information in NUREG 0700, *Human-System Interface Design Review Guidelines*; ANSI/ISA 18.2, *Management of Alarm Systems for the Process Industries*; and other HFE references given in Table G-1 of DOE-STD-1195-201.	DOE-STD-1195-2011, Section 2.7
10	Does the HFE process follow the applicable requirements of DOE O 414.1D for software and hardware configurations?	DOE-STD-1195-2011, Section 2.7
11	Does the human-factors design consider and accommodate the range from a 5th-percentile female to a 95th-percentile male within the use population unless alternate upper and lower ranges are specified by DOE?	DOE-HDBK-1140-2001 [31], Section 1.1.3
12	Does the human-factors design address systems, subsystems, equipment, and facilities with regard to unitization, modularization, and standardization?	DOE-HDBK-1140-2001, Section 2.1
13	Does the human-factors design address systems, subsystems, equipment, and facilities with regard to unit layout, mounting, and configuring?	DOE-HDBK-1140-2001, Section 2.2
14	Does the human-factors design address labeling, marking, and coding?	DOE-HDBK-1140-2001, Section 2.3
15	Does the human factors design address equipment accessibility?	DOE-HDBK-1140-2001, Section 2.4
16	Does the human-factors design address controls, displays, and protective devices?	DOE-HDBK-1140-2001, Section 2.5
17	Does the human-factors design address line and cable design? Note: *Line* refer to any single length of pipe, wire, or tubing. *Cable* refers to a number of lines bound together within a single, permanent sheath.	DOE-HDBK-1140-2001, Section 2.6
18	Does the human-factors design address connector design?	DOE-HDBK-1140-2001, Section 2.7
19	Does the human-factors design address test and service point design?	DOE-HDBK-1140-2001, Section 2.8
20	Does the human-factors design address test-equipment design?	DOE-HDBK-1140-2001, Section 2.9
21	Does the human-factors design address cover, case, and shield design?	DOE-HDBK-1140-2001, Section 2.10
22	Does the human-factors design address fastener design and application?	DOE-HDBK-1140-2001, Section 2.11
23	Does the human-factors design address drawer and rack design guidance?	DOE-HDBK-1140-2001, Section 2.12
24	Does the human-factors design address handle and grasp-area design guidance?	DOE-HDBK-1140-2001, Section 2.13
25	Does the human-factors design address maintenance safety?	DOE-HDBK-1140-2001, Section 2.14
26	Does the human-factors design address workspace and operations in non-workshop areas?	DOE-HDBK-1140-2001, Section 3.1
27	Does the human-factors design address facility design for work in radiological areas guidance?	DOE-HDBK-1140-2001, Section 3.2

[30] DOE-STD-1195-2011, provides requirements and guidance for the design, procurement, installation, testing, maintenance, operation, and quality assurance of safety instrumented systems (SIS) that may be used at DOE nonreactor nuclear facilities for safety significant (SS) functions.

[31] DOE-HDBK-1140-2001, *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance,* provides DOE contractors with information that can be used to design equipment and maintenance programs in order to reduce human errors and subsequently accidents and injuries due to human errors with maintenance activities.

	Set 12: Human Factors Lines of Inquiry (LOIs)	Reference
28	Does the human-factors design address workshop requirements?	DOE-HDBK-1140-2001, Section 3.3
29	Does the human-factors design address radiological workshops guidance?	DOE-HDBK-1140-2001, Section 3.4
30	Does the human-factors design address other shop and office areas?	DOE-HDBK-1140-2001, Section 3.5
31	Does the human-factors design address storage areas?	DOE-HDBK-1140-2001, Section 3.6
32	Does the human-factors design address maintenance support equipment?	DOE-HDBK-1140-2001, Chapter 4

LOI Set 13: Safeguards and Security

	Set 13: Safeguards and Security Lines of Inquiry (LOIs)	Reference
1	Prior to Critical Decision-1, have general safeguards and security requirements been made for the recommended alternative and preliminary identification of alternatives, including facility design and the incorporation of safeguards and security technologies?	DOE O 413.3B, Appendix C, Section 25
2	Have these alternatives been evaluated with respect to their impact on mission needs, satisfaction of other requirement (such as safety), and other cost considerations?	DOE O 413.3B, Appendix C, Section 25
3	Have this input been incorporated into the conceptual design requirements for further development?	DOE O 413.3B, Appendix C, Section 25
4	Prior to Critical Decision-2, has a Preliminary Security Vulnerability Assessment been conducted to account for the set of safeguards and security requirements and to evaluate the methods selected to satisfy those requirements and address any potential risk-acceptance issues?	DOE O 413.3B, Appendix C, Section 25
5	Have the Project Execution Plan and Performance Baseline been reviewed to ensure that cost, schedule, and integration aspects of safeguards and security have been addressed, all feasible risk mitigation have been identified, and concerns for which explicit line-management risk acceptance are supported?	DOE O 413.3B, Appendix C, Section 25
6	Have the selected methods been evaluated to satisfy the requirements and address any potential risk acceptance issues?	DOE O 413.3B, Appendix C, Section 25
7	Prior to Critical Decision-3, has the final Security Vulnerability Assessment Report been finalized?	DOE O 413.3B, Appendix C, Section 25
8	• Is a site security program representative assigned to the project and work with the FPD and other subject-matter experts (SMEs)? • Is the SME part of the Integrated Project Team?	DOE G 413.3-3A, Section II
9	Are security, project management, and safety professionals interfacing to identify and resolve any potential conflicts and/or identify risks that can impact (1) safety, (2) the achieving of Design Basis Threat objectives, and (3) project costs?	DOE-STD-1189-2016, Appendix E.12
10	Are the security protection schemes coordinated with the design as they relate to safety regarding (1) structural design, and (2) inadvertent or accidental discharge of weapons or weapons systems?	DOE-STD-1189-2016, Appendix E.12
11	Do the interfaces between (1) safeguards and security and (2) safety basis development include the development of Safeguard Requirements Identification, Vulnerability Assessment, and participation in hazard analysis effort?	DOE-STD-1189-2016, Appendix E.12
12	Has the project applied the requirements of DOE Graded Security Protection Policy?	470 series of DOE Directives
13	Have all the security targets been identified, including government and private property, UCI, unclassified cyber systems, and people?	470 series of DOE Directives
14	Are there radiological, chemical, and biological sabotage targets identified for the project?	470 series of DOE Directives
15	Has the project established protection strategies as required DOE Directives?	470 series of DOE Directives
16	Have protection strategies been developed, such as using access-control procedures, information compartmentalization, physical barriers, locks and keys, material controls, employee awareness, and training for areas such as Government property; unauthorized entry, trespass, site intruder, or terrorist; emergency response, and personnel and vehicle inspection?	470 series of DOE Directives

	Set 13: Safeguards and Security Lines of Inquiry (LOIs)	Reference
17	Has the project established and implemented physical-protection requirements?	470 series of DOE Directives
18	Has the project incorporated and implemented Protective Force requirements established by DOE Directives?	470 series of DOE Directives
19	If appropriate, has the project/facility incorporated and implemented Material Control and Accountability requirements?	470 series of DOE Directives
20	Has the project incorporated and implemented Personnel Security requirements?	470 series of DOE Directives
21	Has the project incorporated and implemented cyber security requirements?	• 470 series of DOE Directives • 205 series of DOE Directives
22	Are critical security and surveillance systems and devices being tested?	470 series of DOE Directives

LOI Set 14: Pressure Safety

	Set 14: Pressure Safety Lines of Inquiry (LOIs)	Reference
1	During the design process, have written and documented safety policies and procedures been established to ensure that all pressure vessels and systems are designed, fabricated, tested, procured, inspected, maintained, repaired, and operated by trained and qualified personnel in accordance with applicable and sound engineering principles?	• 10 CFR 851, Appendix A, Section 4, *Pressure Safety* • DOE O 440.1B, Attachment 1, Section 7
2	Have the designers ensured that all pressure vessels, boilers, air receivers, and supporting piping systems conform to the codes and standards listed in 10 CFR 851 and in DOE O 440.1B, including the following? • ASME Design and Construction of Boiler, Air Receivers, and Pressure Vessels • ANSI/ASME B.31 Piping Code • National Board Inspection Code NB-23 • Department of Transportation, 49 CFR Parts 100-199 • Strictest applicable state and local codes	• 10 CFR 851, Appendix A, Section 4 • DOE O 440.1B, Attachment 1, Section 7
3	Have all the applicable codes and standards been considered for the design of safety-significant and safety-class process equipment?	DOE O 420.1C, Attachment 3, Table 2
4	Are the codes and standards used in the design part of the Code of Record?	DOE G 420.1-1A, Section 5.4.1.6
5	If national consensus codes are not applicable, have implementing measures been established to provide equivalent protection and ensure safety equal to or superior to the intent of the ASME code?	• 10 CFR 851, Appendix A, Section 4 • DOE O 440.1B, Attachment 1, Section 7
6	Do the implementing measures meet the following criteria? • Design drawings, sketches, and calculations must be reviewed and approved by an independent design professional. Documented organizational peer review is acceptable. • Qualified personnel must be used to perform examinations and inspections of materials, in-process fabrications, nondestructive tests, and acceptance tests. • Documentation, traceability, and accountability must be maintained for each pressure vessel or system, including descriptions.	• 10 CFR 851, Appendix A, Section 4 • DOE O 440.1B, Attachment 1, Section 7
7	Have the design, pressure ratings, traceability, inspection, testing, operations, repair, and maintenance requirements been described and documented for each pressure vessel or system?	• 10 CFR 851, Appendix A, Section 4 • DOE O 440.1B, Attachment 1, Section 7
8	Are qualified personnel in control of the design, selection, and use of the pressure hardware, including quality-control requirements, procurement specifications, and assembly of pressure components?	• 10 CFR 851, Appendix A, Section 4 • DOE O 440.1B, Attachment 1, Section 7
9	Are the personnel who design, build, and operate pressure systems trained and qualified through documented formal classroom attendance, testing, and on-the-job experience and/or training?	DOE O 440.1B, Attachment 1, Section 7
10	Has it been established that the worker and safety provisions of the 10 CFR 851 Rule do not supersede requirements in 10 CFR Part 830, Nuclear Safety Management, and the appropriate sections of the ASME Boiler and Pressure Vessel Code that more appropriately apply to nuclear reactors and other DOE nuclear facilities?	DOE G 440.1B, Section 8.4

LOI Set 15: Environmental Protection

	Set 15: Environmental Protection Lines of Inquiry (LOIs)	Reference
1	Prior to Critical Decision-1 during conceptual design, has a National Environmental Policy Act (NEPA) Strategy been completed by issuing a determination, such as an Environmental Assessment?	• DOE O 413.3B, Chg 2 • DOE O 451.1B, Admin Chg 3 • DOE-STD-2016, Appendix E.13
2	Has an Environmental Compliance Strategy been prepared, including a schedule for timely acquisition of required permits and licenses?	DOE O 413.3B, Chg 2
3	Prior to Critical Decision-2, is the final Environmental Impact Statement or Environmental Assessment and Finding of No Significant Impact issued, as required by 10 CFR Part 1021?	• DOE O 413.3B, Chg 2 • DOE O 451.1B, Admin Chg 3
4	For an Environmental Impact Statement, has the appropriate authority issued the Record of Decision after CD-2 is granted, but prior to CD-3 approval?	• DOE O 413.3B, Chg 2 • DOE O 451.1B, Admin Chg 3
5	At 90% design completion of the nuclear project, is environment protection part of the independent technical reviews of the final drawings and specifications?	DOE O 413.3B, Chg 2
6	During facility design, has the contractor developed and implemented an Environmental Management System (EMS)?	• DOE O 436.1 • DOE O 413.3B, Chg 2
7	Is the EMS certified to, or in conformance with, the International Organization for Standardization requirements?	DOE O 436.1, *Contractor Requirements Document* (CRD)
8	Are the site sustainability goals integrated into the EMS?	DOE O 436.1 CRD
9	Prior to Critical Decision-4, is the EMS revised prior to start of operations or project completion?	• DOE O 413.3B, Chg 2 • DOE O 436.1
10	Have interfaces been performed with other project areas, such as consistency in treatment in accident analysis, with the facility safety-basis evaluation?	Best Engineering Practice (BEP)

LOI Set 16: Emergency Preparation

	Set 16: Emergency Preparedness Lines of Inquiry (LOIs)[32]	Reference
1	During the facility design process, has an emergency-management program been established as part of the site's Comprehensive Emergency Management System?	DOE O 151.1D, Attachment 3, Section 1
2	Has an individual been designated to administer the emergency management program with the responsibilities defined in DOE O 151.1D?	DOE O 151.1D, Attachment 3, Section 1
3	Does the emergency management program address the elements of the Emergency Management Core Program (EMCP) as defined in DOE O 151.1D?	DOE O 151.1D, Attachment 3, Section 1
4	In addition to the requirements of EMCP, are the following DOE O 151.1D requirements being implemented? • Emergency Management Hazardous Material Program (EMHMP) • Secure Transportation • Energy Emergency Response Support	DOE O 151.1D, Attachment 3, Section 1
5	As part of the design process, is an All-Hazards Survey (AHS) being performed to identify all hazards that are applicable to the facility operation, and to establish the planning basis for the emergency management program? Note: The AHS may cover single or multiple facilities, or one AHS may cover an entire site.	DOE O 151.1D, Attachment 3, Section 2
6	Does the AHS address the following elements? • Description of the potential health, safety, or environmental impacts • The need for development of further planning and preparedness beyond the EMCP • Approval of the DOE approval • Performance of an AHS, including natural hazards, technological hazards, and human-caused incidents • A threat and Hazard Identification and Risk Assessment in accordance with the *Homeland Security Comprehensive Preparedness Guide*, CPG 201 • Coordination with local and regional offsite responders for severe events • The hazardous-material screening process (HMSP)	DOE O 151.1D, Attachment 3, Section 2
7	Does the HMSP address the guidelines and criteria of DOE O 151.1D for radiological materials, hazardous biological agents and toxins, and hazardous chemicals?	DOE O 151.1D, Attachment 3, Section 2 e
8	During the design process, have the emergency preparedness experts worked together with the designers and safety analysts to define • major hazards and selection of the less hazardous options? • early recognition of events that have a potential effect on workers and the public? • instrumentation, hardware, and related requirements into the design, including safe shutdown or walkaway strategies? • provisions in the design which may be appropriate to support emergency recovery and reentry?	DOE-STD-1189-2016, Appendix E.7 DOE O 151.1D, Attachment 3, Sections 3 and 4
9	Is the Emergency Operations Systems considered in the design to provide centralized collection, validation, analysis, and coordination of emergency information?	DOE O 151.1D, Attachment 3, Section 4

[32] The review teams can develop additional LOIs from the review of the following DOE O 151.1D guides: (1) DOE G 151.1-1A, *Emergency Management Fundamentals and the Operational Emergency Base Program*; (2) DOE G 151.1-2, *Technical Planning Basis*; (3) DOE G 151.1-3, *Programmatic Elements*; (4) DOE G 151.1-4, *Response Elements*; and (5) DOE G 151.1-5, *Biosafety Facilities*.

	Set 16: Emergency Preparedness Lines of Inquiry (LOIs) [32]	Reference
10	During the facility design process, has an Emergency Management Hazardous Material Program (EMHMP) been established and maintained in addition to the Emergency Management Core Program (EMCP)? Note: The EMHMP is required if the facility will contain hazardous materials that were not screened out by the hazardous-material screening process.	DOE O 151.1D, Attachment 4
11	Has an Emergency Planning Hazards Assessment (EPHA) been prepared and used to define the provisions of the EMHMP?	DOE O 151.1D, Attachment 4, Section 2
12	Does the EPHA address the requirements of DOE O 151.1D, including the following? • Identify hazards and consequences from unplanned releases. • Identify reception locations. • Identify the analyzed scenarios. • Determine the Emergency Planning Zone and obtain DOE approval. • Document the EPHA assumptions, methodology, models, and evaluation techniques. • Coordinate and interface with the hazard assessments of nuclear safety-basis development and environmental assessment.	DOE O 151.1D, Attachment 4, Section 2

LOI Set 17: Technology Readiness

	Set 17: Technology Readiness Lines of Inquiry (LOIs)	References
1	Prior to Critical Decision-1 (CD-1) approval, has a Technology Readiness Assessment (TRA) been conducted and a Technology Maturation Plan (TMP) been developed, as appropriate? Note: The TRA and TMP are required for Major Systems Projects or first-of-the-kind engineering endeavors.	DOE O 413.3B, Chg 2, Appendix A, Table 2.1
2	At this project stage, has each critical technology item or system achieved a Technology Readiness Level-4 (TRL-4)? Note: See the TRL description in DOE G 413.3-4A.	• DOE O 413.3B, Chg 2, Appendix A, Table 2.1 • DOE G 413.3-4A
3	Has the Project Management Executive (PME) approved the TRA and TMP during CD-1?	DOE O 413.3B, Chg 2, Appendix A, Table 2.1
4	Prior to Critical Decision-2 (CD-2) approval, has a TRA been conducted and a Technology Maturation Plan (TMP) been developed or updated?	DOE O 413.3B, Chg 2, Appendix A, Table 2.2
5	At this project stage, has each critical technology item or system achieved a Technology Readiness Level-7 (TRL-7)?	• DOE O 413.3B, Chg 2, Appendix A, Table 2.2 • DOE G 413.3-4A
6	Has the PME approved the TRA and TMP during CD-2?	DOE O 413.3B, Chg 2, Appendix A, Table 2.2
7	Prior to CD-3 approval, for Major System Projects where a significant critical technology element modification occurs subsequent to CD-2, has a TRA been conducted?	DOE O 413.3B, Chg 2, Appendix A, Table 2.3
8	Has the Program Secretarial Officer (PSO) approved the TRA during CD-3?	DOE O 413.3B, Chg 2, Appendix A, Table 2.3
9	Has the project/program implemented a Technology Development Plan (TDP) consistent with the guidance in DOE G 413.3-4A?	DOE G 413.3-4A, Section 1.3.1
10	Is the TDP a comprehensive planning document describing technology development activities required for the successful execution of the project, and the development relationship to the overall project scope and schedule relative to project phases?	DOE G 413.3-4A, Section 1.3.1
11	Does the TDP address process needs identification, selection, system engineering, evaluation, performance verification, and demonstrations?	DOE G 413.3-4A, Section 1.3.1
12	Has a technical risk assessment been performed to identify risks that may affect the achievement of technical objectives that ultimately affect cost, schedule, and performance?	DOE G 413.3-4A, Section 1.3.1
13	• Are the results of technology development assessments documented and reviewed to determine the validity of the approach that best meets project goals, objectives, and the physical, functional, performance, and operational requirements of the project at the best value? • Do the results of technology development assessments documented and reviewed include testing and validation of all required functions, including any safety functions?	DOE G 413.3-4A, Section 1.3.1
14	Has performance verification been completed following design and before beginning construction?	DOE G 413.3-4A, Section 1.3.1
15	Has the verification process addressed the effect of the selected process or equipment on performance, both at the component level and from an integrated system perspective?	DOE G 413.3-4A, Section 1.3.2
16	Has the project established Integrated Project Review (IPR) teams to conduct TRA reviews?	DOE G 413.3-4A, Section 1.3.4

	Set 17: Technology Readiness Lines of Inquiry (LOIs)	References
17	Has the project implemented a TRA Process model consistent with the guidance of DOE G 413.3-4A?	DOE G 413.3-4A, Section 2
18	Does the TRA process model include the following three sequential steps? Step 1 Identify the Critical Technology Elements (CTEs). Step 2 Assess the TRL. Step 3 Develop the TMP.	DOE G 413.3-4A, Section 2
19	Does the project have a defined process that will ensure the identification of the CTEs consistent with the guidance of Section 3 of DOE G 413.3-4A?	DOE G 413.3-4A, Section 3
20	Does the project have a defined process that will ensure the identification of the TRL consistent with the guidance of Section 4 of DOE G 413.3-4A?	DOE G 413.3-4A, Section 4
21	Does the project have a defined process that will ensure the development of a TMP consistent with the guidance of Section 5 of DOE G 413.3-4A?	DOE G 413.3-4A, Section 5
22	Are the basic chemical processes an exact replication of the processes at another facility?	Best Engineering Practice (BEP)
23	Are the basic chemistries analyzed and tested at full scale, and proven by analysis and tests?	BEP
24	Is the proof of process based on a pilot plant?	BEP
25	Are all the chemical designs (principal and supporting systems) completed, verified, and tested?	BEP
26	Are the quantities, toxicity, flammability, criticality, OSHA regulated-potential, of all flow streams and stored materials characterized?	BEP
27	Is the process hazard analysis (event trees and fault trees, HAZOP, "what if," et at.) completed?	BEP
28	Is there a potential for runaway reactions, by off-specification chemistries, contaminants, in-leakage of air, water or heat-transfer liquid, loss of agitation or mixing, hot spots, delayed reactions, backflow, excessive preheating, loss of purge, loss of inerting gas, or other manner?	BEP
29	Are the analyses of rates of heat and gas evolution from reactions or decomposition completed?	BEP
30	Is there a potential for exothermic reactions?	BEP
31	Is there a potential for explosion (deflagration or detonation)?	BEP
32	Have alternatives been studied to minimize hazardous (toxic, flammable, pyrophoric, volatile, contaminated) materials inventory?	BEP
33	Have alternatives been studied to minimize hazardous reactions?	BEP
34	Have alternatives been studied to prevent criticality?	BEP
35	Have alternatives been studied to reduce radiation levels and facilitate access for inspections and maintenance?	BEP
36	Have alternatives been studied to reduce radiation contamination?	BEP
37	Have alternatives been studied for the use of lower-energy systems (systems with a lower pressure or temperature)?	BEP
38	Is the plant designed with redundancy to permit single active failure of critical equipment or components following the design-basis accident?	BEP
39	Is the basis for the throughput predictions provided?	BEP
40	Are the physical characteristics (viscosity, boiling point, melting point, vapor pressure, et al.) of the process fluids characterized and tested?	BEP
41	Are the hydraulic mixing, blending, and separation processes verified and tested?	BEP

	Set 17: Technology Readiness Lines of Inquiry (LOIs)	References
42	Is the potential for settlement, heels, buildup, and blockage analyzed and tested?	BEP
43	What is the safety logic underpinning the system design (interlocks, operator actions, et al.)?	BEP
44	Are the flow rates and heat transfers designs of the basic chemical systems completed and verified by tests?	BEP
45	Are the flow rates and heat transfers designs of the secondary systems completed and verified by tests?	BEP
46	Are the process flow diagrams complete and verified for all systems?	BEP
47	Are the P&ID complete and verified for all systems?	BEP
48	Are the systems protected from overpressure (relief systems, flares, et al.)?	BEP
49	Is overflow in tanks and basins prevented?	BEP
50	Are the minimum–maximum envelopes of safe operation defined (temperature–pressure, heatup–cooldown rates, flow rates, plugging, loss of flow, loss of relief capacity, product quantities, ambient and environment, natural phenomena hazards, et al.)?	BEP

LOI Set 18: Waste Management

	Set 18: Waste Management Lines of Inquiry (LOIs) [33]	Reference
General LOIs		
1	Are facility process systems designed to minimize waste production and mixing of radioactive, hazardous, and nonradioactive waste? • Are hazardous waste streams (types, sources, and quantities) identified early in the design process and prevention practices—for example, chemical substitution, or use of less hazardous materials—incorporated to reduce waste generation and costs? • Are management strategies (storage, treatment, and disposal systems) described in the documented safety analysis? • Are potential accidental releases from waste management systems addressed during hazards analysis in preliminary and detailed design?	DOE-O-420.1C, Chg 1 DOE-STD-1189-2016, Appendix E.8
2	If mixed or hazardous wastes will be managed, does the facility design of access controls take into account Resource Conservation and Recovery Act requirements for hazardous waste treatment, storage, and disposal facilities?	DOE-G-420.1A, Section 5.4.4
3	Does design to facilitate deactivation incorporate facility features that aid in the removal of surplus radioactive and chemical materials; storage tank cleanout and maintenance; stabilization of contamination and process materials; and the removal of hazardous, mixed, and radioactive wastes?	DOE-G-420.1A, Section 5.4.1
4	Does facility design incorporate waste minimization features such as walls, ceilings, and floors in areas vulnerable to contamination, which are finished with washable or strippable coverings? • Are metal liners used in areas that have the potential to become highly contaminated? • Are cracks, crevices, and joints filled and finished smooth to prevent the accumulation of contaminated material and thus minimize the generation of waste during operation, maintenance, and decommissioning?	DOE-G 420.1A, Section 5.4.1
5	Are liquid radioactive and hazardous waste-collection, transfer, and storage systems designed to avoid the dilution of radioactive or hazardous waste by waste that has lower concentrations of radioactivity, toxicity, or other hazard?	DOE-G 420.1A, Section 5.4.6
6	Are waste management and storage systems (unless it has been demonstrated that the risk is acceptable) designed to • remain functional following a design basis accident? • facilitate the maintenance of a safe shutdown condition?	DOE-G 420.1A, Section 5.4.7
High-Level Waste (HLW) LOIs		
7	Is at least one confinement barrier designed to withstand the effects of design-basis accidents?	DOE-G 420.1A, Section 5.4.7
8	• Has a radioactive waste-management basis document for the management of HLW been developed during facility design? • Does the basis document include o a generator waste certification program? o a waste acceptance and certification requirements for pre-treatment, treatment, and storage facilities?	DOE-M 435.1-1, Chapter II, Requirement F

[33] This set of LOIs is broken down to cover design expectations for (1) general waste management; (2) HLW facilities; (3) TRU facilities; and (4) LLW facilities. The Design Review Team should also consider other engineering and technical areas LOIs for waste-management design review.

	Set 18: Waste Management Lines of Inquiry (LOIs) [33]	Reference
9	As part of site evaluation, are proposed locations for the HLW facility evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses, including environmental characteristics, geotechnical characteristics, and human activities?	DOE-M 435.1-1, Chapter II, Requirement P(1)
10	Are Safety Class and Safety Significant Structures, Systems, and Components for the HLW storage, pre-treatment, or treatment facility designed in a manner consistent with DOE O 420.1C, DOE 5480.22, and DOE 5480.23?	DOE-M 435.1-1, Chapter II, Requirement P(a)
11	Are confinement (secondary confinement systems and welded construction requirements for piping systems) requirements adhered to?	DOE-M 435.1-1, Chapter II, Requirement P(b)
12	Are lifting devices designed as safety-class or safety-significant systems with interlocks, which will fail safe?	DOE-M 435.1-1, Chapter II, Requirement P(c)
13	Do ventilation systems use appropriate filtration to maintain the release of radioactive material in airborne effluents within the applicable requirements, maintain potentially flammable and/or explosive mixtures at non-flammable and non-explosive concentrations, and prevent deflagration or detonation?	DOE-M 435.1-1, Chapter II, Requirement P(d)
14	Does facility design consider future decontamination and decommissioning?	DOE-M 435.1-1, Chapter II, Requirement P(e)
15	Is maintaining personnel radiation exposures ALARA incorporated into the design of the HLW facility?	DOE-M 435.1-1, Chapter II, Requirement P(f)
16	Do storage facilities incorporate means for waste retrieval and complement existing storage facilities for safe HLW transfer?	DOE-M 435.1-1, Chapter II, Requirement P(g)
17	Does the design of a HLW storage tank • address confinement requirements by avoiding or minimizing critical degradation rates? • incorporate features to facilitate structural integrity program execution?	DOE-M 435.1-1, Chapter II, Requirement P(h)
18	Are instrumentation and controls incorporated to provide • volume inventory and monitoring data and prevent spills, leaks, and overflows from tanks or confinement systems? • rapid detection of failed confinement and/or abnormal conditions?	OE-M 435.1-1, Chapter II, Requirement P(i)
19	Are monitoring and/or leak detection capabilities incorporated in the design?	DOE-M 435.1-1, Chapter II, Requirement P(j)
Transuranic Waste (TRU) LOIs		
20	Does the TRU facility have a waste-management basis consisting of physical and administrative controls to ensure the protection of workers, the public, and the environment?	DOE-M 435.1-1, Chapter III, Requirement D
21	Are the following controls included in the radioactive-waste management basis? • Generators with a waste certification program • Treatment facilities with waste-acceptance requirements and a waste-certification program • Storage facilities with waste-acceptance requirements and a waste-certification program • Disposal Facilities with a performance assessment, a disposal authorization statement, waste-acceptance requirements, and a monitoring plan	DOE-M 435.1-1, Chapter III, Requirement D
22	During facility design, has planning been performed to address the entire life cycle for TRU streams?	DOE-M 435.1-1, Chapter III, Requirement H
23	If a TRU stream has no identified path to disposal, has it been generated in accordance, at the minimum, with the following approved conditions? • Programmatic need to generate the waste • Characteristics and issues preventing the disposal of the waste	DOE-M 435.1-1, Chapter III, Requirement H

	Set 18: Waste Management Lines of Inquiry (LOIs) [33]	Reference
	• Safe storage of the waste until disposal can be achieved • Activities and plans for achieving final disposal of the waste	
24	As part of site evaluation, are proposed locations for a TRU facility evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses, including environmental characteristics, geotechnical characteristics, and human activities?	DOE-M 435.1-1, Chapter III, Requirement M(1)
25	Are the TRU systems and components designed to maintain waste confinement?	DOE-M 435.1-1, Chapter III, Requirement M(2)(a)
26	Is the TRU facility designed to include ventilation, if applicable, through an appropriate filtration system to maintain the release of radioactive material within specified requirements and guidelines?	DOE-M 435.1-1, Chapter III, Requirement M(2)(b)
27	Is the ventilation system designed to maintain potentially flammable and/or explosive mixtures at nonflammable and non-explosive concentrations and prevent deflagration or detonation?	DOE-M 435.1-1, Chapter III, Requirement M(2)(b)
28	Are decontamination and decommissioning considerations addressed in the TRU facility design to facilitate decontamination, including impacts on potential for facility reuse?	DOE-M 435.1-1, Chapter III, Requirement M(2)(c)
29	Are instrumentation and control systems incorporated in the TRU facility design and engineering to provide volume inventory data and to prevent spills, leaks, and overflows from tanks or confinement systems?	DOE-M 435.1-1, Chapter III, Requirement M(2)(d)
30	Are monitoring and/or leak detection capabilities incorporated in the TRU facility design to provide rapid identification of failed confinement and/or other abnormal conditions?	DOE-M 435.1-1, Chapter III, Requirement M(2)(e)
Low-Level Waste (LLW) LOIs		
31	Does the LLW facility have a waste-management basis consisting of physical and administrative controls to ensure the protection of workers, the public, and the environment?	DOE-M 435.1-1, Chapter IV, Requirement D
32	Are the following controls included in the radioactive waste management basis? • Generators with a waste certification program • Treatment facilities with waste-acceptance requirements and a waste-certification program • Storage facilities with waste-acceptance requirements and a waste-certification program • Disposal facilities with a performance assessment, a disposal-authorization statement, waste-acceptance requirements, and a monitoring plan	DOE-M 435.1-1, Chapter IV, Requirement D
33	As part of site evaluation, are proposed locations for an LLW facility evaluated to identify relevant features that should be avoided or must be considered in facility design and analyses, including environmental characteristics, geotechnical characteristics, and human activities?	DOE-M 435.1-1, Chapter IV, Requirement M(1)(a)
34	Does the site evaluation include the capability of the site to demonstrate, at a minimum, • whether it is located to accommodate the projected volume of waste to be received? • whether it is located in a flood plain, a tectonically active area, or in the zone of water table fluctuation? • whether it is located where radionuclide migration pathways are predictable and erosion and surface runoff can be controlled? • whether the proposed sites, where adequate protection cannot be provided through facility design, has been documented as unsuitable for the location of the facility?	DOE-M 435.1-1, Chapter IV, Requirement M(2)(a)

	Set 18: Waste Management Lines of Inquiry (LOIs) [33]	Reference
	• the LLW disposal facility is sited to achieve long-term stability and to minimize, to the extent practical, the need for active maintenance following final closure?	
35	LLW Treatment and Storage Facility Design • Are LLW systems and components designed to maintain waste confinement? • Does the design of LLW treatment and storage facility include ventilation, if applicable, through an appropriate filtration system to maintain the release of radioactive material within specified requirements and guidelines? • Does the ventilation system maintain potentially flammable and/or explosive mixtures nonflammable and non-explosive and prevent deflagration or detonation? • Is the facility designed to facilitate decontamination at areas subject to contamination with radioactive or other hazardous materials? • Doe the design address s decommissioning method or a conversion method leading to potential reuse of the facility? • Are instrumentation and controls systems incorporated in the facility design to provide volume inventory data and to prevent spills, leaks, and overflows from tanks or confinement systems? • Are monitoring and/or leak detection capabilities incorporated into the design to provide rapid identification of failed confinement and/or other abnormal conditions?	DOE-M 435.1-1, Chapter IV, Requirement M(2)(a) through (e)
36	Low-Level Waste Disposal Facility Design • Are LLW systems and components designed to maintain waste confinement? • Does the design of LLW facility include, if applicable, an appropriate filtration system to maintain the release of radioactive material within specified requirements and guidelines? • Does the ventilation system maintain potentially flammable and/or explosive mixtures at nonflammable and non-explosive concentrations and prevent deflagration or detonation? • Is the facility designed to achieve long-term stability and to minimize, to the extent practical, the need for active maintenance following final closure? • Is the facility designed to minimize, to the extent practical, the contact of waste with water during and after disposal?	DOE-M 435.1-1, Chapter IV, Requirement M(3)(a) through ((d)
37	Alternate Requirements for LLW Disposal Facility Design and Operation If requirements other than those specified in DOE O 435.1 and associated manual for the design and operation of a LLW disposal facility are implemented, are the alternate requirements approved on a specific basis, has a reasonable expectation been demonstrated that the disposal performance objectives will be met?	DOE-M 435.1-1, Chapter IV, Requirement P(7)

LOI Set 19: D&D Considerations During Design

	Set 19: D&D Considerations Lines of Inquiry (LOIs)	Reference
1	Has the nuclear facility design incorporated features to facilitate safe deactivation, decommissioning, and decontamination at the end of facility life, including incorporation of design considerations during the operational period that facilitate future decontamination and decommissioning?	• DOE O 420.1C, Attachment 2, Chapter I, Section 3.b.(4)(a) • DOE G 420.1-1A, Section 5.4.1 • DOE HDBK-1132-99, Part I, Section 2.12
2	Is the facility designed to facilitate deactivation by incorporating facility features that aid in the removal of • surplus radioactive and chemical materials? • storage tank cleanout and maintenance? • stabilization of contamination and process materials? • the removal of hazardous, mixed, and radioactive wastes?	DOE G 420.1-1A, Section 5.4.1.1
3	Has the facility been designed to incorporate measures to simplify decontamination of areas that may become contaminated with radioactive or hazardous materials?	DOE G 420.1-1A, Section 5.4.1.2
4	Are the design features for decommissioning consistent with the requirements of DOE O 435.1, *Radioactive Waste Management*?	DOE G 420.1-1A, Section 5.4.1.3
5	Have the following design principles been considered for decommissioning? • Use of localized liquid-transfer systems, with emphasis on localized batch solidification of liquid waste to avoid long runs of buried contaminated piping Note: Special provisions should be included in the design to ensure the integrity of joints in buried pipelines. • Location of exhaust filtration components of the ventilation systems at or near individual enclosures to minimize long runs of internally contaminated ductwork • Equipment, including effluent decontamination equipment that precludes, to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas, including curves and turns in piping and ductwork Note: Accessible, removable covers for inspection and cleanouts are encouraged. • Use of modular radiation shielding in lieu of or in addition to monolithic shielding walls • Provisions for flushing and/or cleaning contaminated or potentially contaminated piping systems • Provisions for suitable clearances, where practical, to accommodate remote handling and safety surveillance equipment required for future decontamination and decommissioning • Use of lifting lugs on large tanks and equipment • Use of free draining via gravity in piping systems that carry contaminated or potentially contaminated liquid	DOE G 420.1-1A, Section 5.4.1.3

LOI Set 20: Systems Engineering

	Set 20: Systems Engineering Lines of Inquiry (LOIs)	Reference
1	As part of the project definition and conceptual design development process prior to Critical Decision-1 approval, is systems engineering being implemented for the integration of requirements analysis, risk identification and analysis, acquisition strategies, and concept exploration in order to evolve a cost-effective, preferred solution to meet a mission need?	• DOE O 413.3B, Appendix C, Section 4.b • DOE G 413.3-1, Chg 1 [34]
2	Is systems engineering being implemented by the project Federal Project Director and the Integrated Project Team for the integration of preliminary design activities and for project oversight?	• DOE G 413.3-1, Section 5 • DOE-STD-1189
3	Is systems engineering being implemented for the overseeing and coordination of final design activities?	DOE G 413.3-1, Section 6
4	Are the following systems engineering activities being implemented during the design process? • Identifying and integrating facility nuclear safety requirements • Coordinating multidisciplinary teamwork in implementing facility safety requirements • Providing nuclear safety-related interface management • Providing configuration management, including the establishment of baseline configuration • Coordinating technical reviews of the facility nuclear safety features	Best Engineering Practice (BEP)
5	Have a cognizant system engineer (CSE) program and plan been developed documented during the facility design process prior to Critical Decision-4, Approval of Start of Operations or Project Completion? Note: CSE programs should be established before CD-4 to ensure project stability and operation at CD-4. CSE programs should remain in place as long as the covered systems are credited in the safety basis or designated by facility line management.	• DOE O 420.1C, Attachment 2, Chapter V • DOE-STD-1189
6	• Does the CSE program/plan describe the functions, responsibilities, and authorities of the cognizant system engineers? • Does the CSE program/plan address the following elements? o Identification of systems covered by the CSE program and identification of systems assigned for coverage o Configuration management o Support for operations and maintenance o Training and qualifications of CSEs Note: See LOI Set 21: Configuration Management, on page A-61.	• DOE O 420.1C, Attachment 2, Chapter V, Section 3.a
7	Does the CSE program address active safety-class and safety-significant systems, as defined in the facility's DOE approved safety basis, as well as to other active systems that perform important defense-in-depth functions, as designated by facility line management?	DOE O 420.1C, Attachment 2, Chapter V, Section 3.b.(1)
8	Does the CSE program address the designated systems and the rationale for assignment of CSEs in a graded approach?	DOE O 420.1C, Attachment 2, Chapter V, Section 3.b.(1)

[34] This Guide provides the systems engineering knowledge, methodologies, and tools needed to meet Order 413.3B's requirement for project planning, design, and construction.

	Set 20: Systems Engineering Lines of Inquiry (LOIs)	Reference
9	• Is the CSE program tailored to the potential facility hazards and the systems relied upon to prevent or mitigate those hazards? • Does the program address Remaining Facility Lifetime and the Safety Significance of Remaining Operations? • Does the program address Safety Importance of the System?	DOE O 420.1C, Attachment 2, Chapter V, Section 3.b.(2)
10	During the latter part of the facility design process, have qualified CSEs been identified and assigned to each active system within the scope of the CSE program? Note: Consistent with the graded approach, large, complex, or very important systems may require assignment of more than one CSE. Inversely, a single individual may be assigned to be the CSE for more than one system.	DOE O 420.1C, Attachment 2, Chapter V, Section 3.b.(3)
11	Has operational staff been involved in the design process to ensure proper development of the CSE program?	BEP
12	As part of the CSE program during facility design, has a documented configuration-management program been established and implemented to ensure consistency among system requirements and performance criteria, system documentation, and physical configuration of the systems?	• DOE O 420.1C, Attachment 2, Chapter V, Section 3.c(1) • DOE-STD-1073-2016, *Configuration Management Program*
13	Does the configuration management program address • system design documentation? • system assessments? • control of maintenance? • change control? • obsolescence? Note: See LOI Set 21: Configuration Management, on page A-61.	• DOE O 420.1C, Attachment 2, Chapter V, Section 3.c(1)
14	Have system design documents and supporting documents been identified and kept current, using formal change-control and work-control processes?	• DOE O 420.1C, Attachment 2, Chapter V, Section 3.c(2) • DOE-STD-3024-2011, *Content of System Design Descriptions*
15	Does design documentation include • system requirements and performance criteria essential to performance of the system's safety functions? • the basis for system requirements? • a description of how the current system configuration satisfies the requirements and performance criteria?	DOE O 420.1C, Attachment 2, Chapter V, Section 3.c(2)
16	Do system assessments include periodic reviews of system operability, reliability, and material condition? Note: Reviews must assess the system for the following: • The ability to perform design and safety functions • Physical configuration as compared to system documentation • System and component performance in comparison to established performance criteria	DOE O 420.1C, Attachment 2, Chapter V, Section 3.c(3)

LOI Set 21: Configuration Management

	Set 21: Configuration Management Lines of Inquiry (LOIs)	Reference
1	As part of the facility design process, has the contractor established a configuration management (CM) program, as required by DOE O 420.1C and DOE O 413.3B?	• DOE O 420.1C, Attachment 2, Chapter V, Section 3.c. • DOE O 413.3B, Attachment 1, *Contractor Requirements Document*, Requirement # 9 • DOE G 420.1.1A, Section 5.1.5 • DOE-STD-1189-2016 • DOE-STD-1073-2016
2	Has the design organization prepared and implemented a CM plan as an integrated process for all activities that affect safety-in-design integration as the project moves from inception to operation?	DOE-STD-1189-2016, Section 3.8
3	Has the CM plan been initiated early in the conceptual design process and approved prior to start of preliminary design activities?	DOE-STD-1189-2016, Section 3.8
4	Does the CM plan • specify the process so that the design basis and design requirements are made consistent with the safety analysis process? • specify the process for maintaining CM of safety basis documents? • describe the basis for any graded approach, if used?	DOE-STD-1189-2016, Section 3.8
5	• Does the CM program address subsequent changes to project design and supporting documents? • Does the CM program address the need to establish a formal change-control program in accordance with the requirements of NQA-1, where applicable?	DOE G 420.1.1A, Section 5.1.5
6	Does the CM process control changes to the physical configuration of the facilities, structures, systems, and components in compliance with ANSI/EIA-649B and DOE STD-1073-2016?	DOE O 420.1C, Attachment 2, Chapter V, Section 3.c.
7	Does the CM program address the following? • System design documentation • System assessments • Control of maintenance • Change control • Obsolescence	DOE O 420.1C, Attachment 2, Chapter V, Section 3.c.
8	Are the following five key elements addressed by the CM program as discussed in DOE-STD-1073-2016? • Design control • Work control • Change control • Document control • Assessments	DOE-STD-1073-2016, Section 1
9	For new nuclear facilities, does the CM program address the following design-control elements? • Design requirements • Interim measures • Design authority	DOE-STD-1073-2016, Section 2

	Set 21: Configuration Management Lines of Inquiry (LOIs)	Reference
	• Review • System design descriptions • CM equipment databases • Turnover from design and construction • Design changes • Cognizant system engineer program as required by DOE 420.1C	
10	Is work control incorporated into the CM process and into the work procedures?	DOE-STD-1073-2016, Section 3
11	• Does the CM program specify a formal change-control process for CM SSCs and credited controls? • Does the change-control process specify o identification of changes? o equivalent changes? o consistent and efficient change control processes? o documentation of proposed changes? o review of changes? o independent verifications? o approval? o post-modification testing and training? o identification of the document to be revised?	DOE-STD-1073-2016, Section 4
12	Does the CM program specify how documents are to be controlled consistent with QA Criterion 4 (DOE O 414.1D or 10 CFR. Part 830, Subpart A)?	DOE-STD-1073-2016, Section 5
13	Does document control address • documents to be controlled? • document and record storage? • timeliness? • document retrieval?	DOE-STD-1073-2016, Section 5
14	Are assessments specified to periodically review the performance of the approved CM process, as required by DOE O 414.1D QA criteria 9 and 10?	DOE-STD-1073-2016, Section 6
15	Does the CM program address the following assessment types? • Design assessments, which are conducted to ensure design documents have been updated to reflect changes and accurately reflect the physical configuration of the facility or activity • Construction assessments, which are conducted to ensure that a configuration is managed throughout the construction process for new construction or major modifications • Physical configuration assessments, which are conducted to evaluate the consistency between the physical configuration and the facility or activity documentation • Periodic performance assessments, which are conducted to verify systems and components continue to meet design and performance requirements in their current configurations	DOE-STD-1073-2016, Section 6

LOI Set 22: Nuclear Maintenance Management Program

	Set 22: Nuclear Maintenance Management Program (NMMP) Lines of Inquiry (LOIs) [35]	Reference
1	During final facility design stage, has the development of a NMMP been initiated to address the maintenance of the structures, systems, and components (SSCs) defined by the facility safety-in-design development process?	DOE O 433.1B [36], Chg 1, Section 4 and Attachment 2
2	• Is the NMMP in compliance with the requirements contained in the Contractor Requirements Document (CRD) of DOE O 433.1B? • Has the NMMP been approved by the Field Office Manager and the respective Secretarial Officer (SO) or designee?	DOE O 433.1B, Section 4 and Attachments 1& 2
3	Are the CRD requirements flowed down from the contractor to the subcontractors?	DOE O 433.1B, Attachment 1
4	Are changes to the NMMP reviewed under the unreviewed safety question (USQ) process to ensure that SSCs are maintained and operated within the approved safety basis?	DOE O 433.1B, Section 4 and Attachment 2
5	If a change would result in USQ approval, is it made before the change takes effect?	DOE O 433.1B, Section 4
6	During final design, are periodic self-assessments conducted in accordance with DOE O 226.1B to evaluate the effectiveness of oversight of the NMMP?	DOE O 433.1B, Section 4
7	Is a single maintenance program being implemented to address the requirements of DOE O 433.1B and DOE O 430.1B?	DOE O 433.1B, Section 4
8	Does the NMMP describe the safety-management program for maintenance and reliable performance of the SSCs, which are part of the facility safety basis?	DOE O 433.1B, Attachment 2
9	• Have the Federal and contractor organizations ensured that equivalencies and exemptions from the DOE O 433.1B requirements have been identified, formally documented with supporting justification, and approved in accordance with DOE O 251.1C? • Has concurrence requested from the CTA or designee been accomplished for both exemptions and equivalencies?	DOE O 433.1B, Attachment 2
10	• Does the NMMP description documentation contain, at a minimum, an applicability matrix or a combination of multiple documents? • Does the NMMP o correlate the requirements in DOE O 433.1B Attachment 2 to the applicable facilities? o correlate the implementing documents (procedures, work instructions, et al.) to the specific requirements in the reference cited in the Reference column? o document the basis for applying a graded approach, if applicable?	DOE O 433.1B, Attachment 2
11	Have the Federal and contractor organizations ensured that the NMMP has been identified in the applicable DSA in accordance with 10 CFR 830.204?	DOE O 433.1B, Attachment 2
12	When reviewing the specific NMMP documentation during the final design process, are the following topics addressed?	DOE O 433.1B, Attachment 2, *Specific Requirements*

[35] A safety management program is required by 10 CFR 830.204(b)(5) for maintenance and for the reliable performance of structures, systems, and components (SSCs) at DOE nuclear facilities. The development of a Nuclear Maintenance Management Program (NMMP) should begin during the final design stage. These NMMP Lines of Inquiry (LOIs) can help in the a facility review during final design and corresponding safety basis development.

[36] This order, *Maintenance Management Program for DOE Nuclear Facilities,* was revised in March 2013. It defines the safety management program required by 10 CFR 830.204(b)(5) for maintenance and the reliable performance of structures, systems, and components that are part of the safety basis required by 10 CFR 830.202 at hazard category 1, 2, and 3 DOE nuclear facilities.

Set 22: Nuclear Maintenance Management Program (NMMP) Lines of Inquiry (LOIs) [35]	Reference
• Integration with Regulations, DOE Orders, and Manuals (and their CRDs) • Maintenance Organization and Administration • Master Equipment List • Planning, Scheduling, and Coordination of Maintenance • Types of Maintenance • Maintenance Procedures • Training and Qualification • Configuration Management • Procurement • Maintenance Tool and Equipment Control • Suspect and Counterfeit Items • Maintenance History • Aging Degradation and Technical Obsolescence • Seasonal Facility Preservation • Performance Measures • Facility Condition Inspection • Post-Maintenance Testing	

LOI Set 23: Layout

	Set 23: Layout Lines of Inquiry (LOIs)	Reference
1	Does the building layout provide protection from the hazards associated with handling, processing, and storing of radioactive and/or hazardous materials?	DOE G 420.1-1A [37] Section 5.4.3
2	Does the facility layout provide specific control and isolation of quantities of flammable, toxic, and explosive gases, chemicals, and other hazardous materials admitted to the facility?	DOE G 420.1-1A Section 5.4.3
3	Does the building layout and structural design integrate security considerations with radiation protection considerations, if security considerations are part of the design process? Note: Physical layout and details of proven radiological equipment designs for plutonium facilities are contained in DOE-STD-1128-2008, *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities*.	DOE G 420.1-1A Section 5.4.3
4	Are the facility plot plans completed?	Best Engineering Practice (BEP) [38]
5	Have layout alternatives been studied to prevent cascading effects from accidents (fire, explosions, releases, et al.)?	BEP
6	Have alternatives been studied to provide inspection and maintenance access?	BEP
7	Does the layout account for control-room habitability following design-basis-postulated accidents?	BEP
8	Does the layout account for access for operator actions?	BEP
9	Does the layout account for access for maintenance activities (cranes, pulling heat exchanger bundles, replacing pumps, et al.)?	BEP
10	Are pumps, valves, compressors, and fans grouped and accessible?	BEP
11	Are pipe routings along the primary directions (east–west and north–south)?	BEP
12	Is the number of road crossings minimized, and are crossings sized to permit expected traffic?	BEP
13	Are fire barriers provided where required?	BEP
14	Is access for firefighters and emergency responders included in the design?	BEP
15	Are barriers provided to prevent accidental vehicle impact with SSCs?	BEP
16	Are the civil–structural drawings of buildings completed?	BEP
17	Are the civil–structural drawings of steel structures completed?	BEP
18	Are orthographic drawings of major-equipment layout completed?	BEP
19	Is there a 3-D solid model of the facility?	BEP
20	Is the civil–structural constructability review completed?	BEP
21	Are isometrics for piping completed?	BEP
22	Are isometrics for ducting completed?	BEP
23	Are the electrical and wiring diagrams completed?	BEP
24	Are orthographic drawings or isometrics for cable trays completed?	BEP

[37] This DOE guide, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*, revised in December 2012, provides an acceptable approach for safety design of DOE hazard category 1, 2, and 3 nuclear facilities for satisfying the requirements of DOE Order 420.1C, *Facility Safety*, Attachment 2, Chapter I, *Nuclear Safety Design Criteria*.

[38] Based on lessons learned from DOE and commercial engineering practices.

	Set 23: Layout Lines of Inquiry (LOIs)	Reference
25	Are interferences and constructability of mechanical and electrical equipment and distribution systems completed?	BEP
26	Are storage areas and environments compatible with the materials stored?	BEP
27	Does the layout minimize, and provide protection for, the receipt, handling, and intra-area transport of hazardous materials?	BEP
28	Is the layout free of open ditches or trenches where toxic or flammable vapors could collect?	BEP
29	Does the layout account for security provisions?	BEP
30	Is the potential for future expansion accounted for in the layout?	BEP
31	Do the layout elevations provide for the required slope of lines?	BEP

LOI Set 24: Materials and Corrosion

	Set 24: Materials and Corrosion Lines of Inquiry (LOIs)	Reference
1	Are the following factors being considered in the selection of a material for use in a component design? • Physical, chemical, electrical, and mechanical properties • Weldability • Availability in forms, shapes, sizes, and colors • Insurability, reliability, and safety • Economics, cost/benefit, and initial/life-cycle cost • Effects of the environment on workers and the public • Normal operating conditions, anticipated events, and accidents. • Note: Factors for consideration are contained in design codes, including the codes produced by ASME, American Welding Society, ANSI, and IEEE.	Best Engineering Practice [39] (BEP)
2	Are the following age-related degradation phenomena being considered for metallic materials selection? • General corrosion • Pitting attack • Intergranular corrosion • Stress corrosion • Galvanic corrosion • Crevice corrosion • Erosion corrosion • Microbiological-influenced corrosion • Internal oxidation	BEP
3	Does the metallic selection process consider • all possible degradation and failure modes in addition to mechanical failures? • metallurgy and fabrication processes? • availability of adequate data support and service experience for the specific application? • alloy composition?	BEP
4	Does the nonmetallic selection process consider • thermal properties, including temperature stability? • chemical properties, stability/resistance to chemicals? • radiation resistance? • electrical properties? • physical properties, including water/moisture absorption and odor? • mechanical properties? • the use of thermoset materials vs. thermoplastic? • flammability rating?	

[39] Many of the BEPs are described in DOE-HDBK-1132-99, *Design Considerations*, which was developed in 1999 and reaffirmed in 2014. The handbook contains good design practices based on lessons learned from various design, construction, startup, and operations experiences. Part II, Good Practices, Section 5, Material Considerations, contains the BEPs for materials and corrosion. Also, many of the BEPs are based on lessons learned from current industry experience.

	Set 24: Materials and Corrosion Lines of Inquiry (LOIs)	Reference
	• optical properties, including whether the material should be transparent, translucent, or opaque?	
5	Are the following considerations being evaluated for material selection for process service? • Design life and performance requirements • Expected or actual stream analysis of the process flow • Expected operating pressures and temperatures of the process streams • Desired material mechanical properties • Calculated or expected design radiation dose over the design life of the system • Expected environmental conditions • The need for material decontamination if the process service is radioactive • Historical materials documenting performance experience with similar process streams and operating conditions	BEP
6	Are the following factors being addressed for welding, fabrication, examination, and testing? • Certain metallic materials may be susceptible to cracking during or following welding. • Some process services may require special heat treatments to reduce the risks of stress-corrosion cracking. • Welding, hot forming, and heat-treatment operations on certain materials may degrade their corrosion resistance. • Welding process restrictions may be needed for certain materials. • Some welding processes may not be suitable for certain materials or material thicknesses. • When welding is required on austenitic stainless steels, it may be advisable to use only the low-carbon grades (such as 304L and 316L), or to use controlled-heat-input weld processes, to reduce susceptibility to intergranular-corrosion or intergranular-stress-corrosion cracking. • Certain contaminants on materials may be harmful during welding and should be controlled. • Special welding techniques to provide oxide-free welds should be considered for materials in tritium service. • It might be desirable to use qualified welding procedures and qualified welding personnel for all welded fabrication.	BEP
7	Are the following factors being considered for the control of material corrosion and degradation caused by radiation? • Limitations on the halogen content of materials that contact austenitic stainless steels • Corrosion testing of austenitic stainless steels and nickel-based alloys • For buried metallic structures, use of cathodic protection, external coatings, hydrophobic backfill materials, or combinations of these • Use of internal cathodic protection systems and/or coating of the inside of metallic water-storage tanks • Possible microbiological-influenced corrosion (MIC) of piping systems conveying natural waters or tanks containing natural waters • Dissimilar metal connections, which in certain environments may be prone to accelerated corrosion (galvanic corrosion) • Corrosion caused by trapped moisture under insulation in outdoor piping and vessels • Aluminum and aluminum alloys to be embedded in concrete, which will need to be isolated from the concrete material to reduce corrosion concerns • Limiting the use of polymeric and fiberglass materials • Limitations on the use of polymeric materials exposed to ionizing radiation • Effects of gamma radiation on polymeric materials	BEP

	Set 24: Materials and Corrosion Lines of Inquiry (LOIs)	Reference
	• Effect of heat treatment, microstructure, and composition of alloy materials	
8	Are the fluids and their corrosivity defined for each basic process system and subsystem?	BEP
9	Are the fluids and their corrosivity defined for each support and utility process system and subsystem?	BEP
10	Are the operating conditions (max.–min. flow rates, including stagnant conditions, pressures, and temperatures) defined for each fluid in the basic systems and subsystems?	BEP
11	Are the operating conditions (flow rates (max.–min. including no-flow regimes), pressures, and temperatures) defined for each fluid in the support and utility systems and subsystems?	BEP
12	Are the ambient environmental conditions defined for normal operation and postulated accidents, for each area of the facility (humidity, temperature, chemistries, radiation, et al.)?	BEP
13	Are metallic materials and weld metals selected on the basis of extensive successful experience in identical conditions, for the same design life?	BEP
14	Are nonmetallic materials selected on the basis of extensive successful experience in identical conditions, for the same design life?	BEP
15	For the basic process systems, have all damage mechanisms been evaluated on a subsystem basis—wall thinning (erosion-corrosion), cracking (corrosion, fatigue), embrittlement (hydrogen, radiation, high temperature, low temperature, et al.?	BEP
16	For the secondary and utility systems, have all damage mechanisms been evaluated on a subsystem basis—wall thinning (erosion-corrosion, MIC), cracking (corrosion, fatigue), embrittlement (hydrogen, radiation, high temperature, low temperature, et al.?	BEP
17	If identical environments are lacking, have simulation tests been conducted successfully in accordance with ASTM or NACE standards?	BEP
18	For the basic process systems, have the inner linings or outer coatings been proven for identical service and design life?	BEP
19	If there is a need to monitor the material in service, are arrangements in place for periodic inspection and replacements?	BEP
20	Have there been alternative life-cycle cost studies for costly alloys?	BEP
21	Are the welding processes standard for all materials selected?	BEP
22	Is there a need for in-service chemistry controls, and is it reflected in the system design?	BEP
23	Are the physical properties of the material (strength, hardness, toughness, elasticity, et al.) compatible with the range of operating conditions, accidents, and environments?	BEP
24	Have industry and complexwide lessons-learned been studied to support material selection?	BEP
25	Has material selection been reviewed with construction for feasibility of procurement, fabrication, and erection?	BEP
26	Are materials and welding compliant with the design codes?	BEP
27	Are selected joining techniques (welding, flange, couplings, et al.) compatible with the service?	BEP
28	Are selected joining techniques (welding, flange, couplings, et al.) compatible with inspection and maintenance access?	BEP
29	Is the design life of each basic process system, subsystem, and component, defined, and, if it is shorter than the facility design life, are there access provisions in the design for replacement?	BEP

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Appendix B Design Process Continuum and Its Relationship to DOE Critical Decision and Safety Basis Development Processes