U.S. Department of Energy
Washington, D.C.

ORDER

DOE O 420.1C

Approved: 12-4-2012
Chg 1 (PgChg): 2-27-2015
Chg 2 (MinChg): 7-26-2018
Chg 3 (LtdChg): 11-14-2019

SUBJECT: FACILITY SAFETY

1. OBJECTIVE. To establish facility and programmatic safety requirements for the Department of Energy (DOE), including the National Nuclear Security Administration (NNSA), for:

   a. Nuclear safety design criteria;

   b. Fire protection;

   c. Criticality safety;

   d. Natural phenomena hazards (NPH) mitigation; and,

   e. Cognizant system engineer (CSE) program.

   Facility safety requirements for explosive, chemical, and industrial hazards are contained in other DOE rules and directives.

2. CANCELLATIONS. This Order (O) cancels: DOE O 420.1C Chg. 2, *Facility Safety*, dated 7-26-08; and DOE O 5480.30 Chg. 1*, Nuclear Reactor Safety Design Criteria,* dated 3-14-01.

   Cancellation of a directive does not, by itself, modify, or otherwise affect any contractual or regulatory obligation to comply with the directive. Contractor Requirements Documents (CRDs) that have been incorporated into a contract remain in effect throughout the term of the contract unless, and until, the contract or regulatory commitment is modified to either eliminate requirements that are no longer applicable or to substitute a new set of requirements.

3. APPLICABILITY.

   a. Departmental Applicability. This Order applies to all DOE elements with responsibility for design, construction, management, operation, decontamination, decommissioning, or demolition of government-owned or government-leased facilities and contractor-leased facilities used for DOE mission purposes.

      The NNSA Administrator will ensure that NNSA employees comply with their respective responsibilities under this directive. Nothing in this Order will be construed to interfere with the NNSA Administrator's authority under section 3212(d) of Public Law (Pub. L.) 106-65, *National Defense Authorization Act for Fiscal Year 2000*, to establish Administration-specific policies, unless disapproved by the Secretary.

b. DOE Contractors. Except for the equivalencies and exemptions in Section 3.c, the CRD (see Attachment 1 of this Order) sets forth requirements of this Order that will apply to contracts that include the CRD. The CRD, or its requirements, must be inserted into all contracts that require design, construction, management, operation, decontamination, decommissioning, or demolition of government-owned and government-leased facilities. For leased facilities that are not nuclear hazard category 1, 2, or 3 facilities, the requirements of the CRD apply to the extent determined by the DOE Head of Field Element.

c. Equivalencies and Exemptions.

(1) Requests for equivalencies and exemptions to the requirements of this Order are processed in accordance with DOE O 251.1D, *Departmental Directives Program*. Central Technical Authority (or designee) concurrence is required for both exemptions and equivalencies to the requirements of this Order for nuclear facilities. Because this Order affects nuclear safety, requests for advice from the Office of Primary Interest (i.e., Office of Nuclear Safety) on proposed equivalencies and exemptions for nuclear facilities should allow 45 days, in accordance with DOE O 251.1D. (Note: This paragraph applies to requirements of this Order related to DOE technical standards and industry codes and standards that are invoked as required methods by this Order. If such invoked technical standards and industry codes include provisions for relief, those provisions govern. Authority to review and approve exemptions and equivalencies may be delegated in accordance with DOE O 450.2, *Integrated Safety Management*, Appendix A, "Delegations of Authority to Perform Safety Management Functions;" such delegations are encouraged whenever the field element has sufficient staff and expertise to oversee the subject matter.)

(2) Equivalencies to DOE technical standards, as well as industry codes, and standards, determined to be applicable to the facility design or operations must demonstrate an equivalent level of safety (i.e., meets or exceeds the level of protection) and must be approved by the DOE Head of Field Element. The DOE Head of Field Element must follow provisions for relief if specified in DOE technical standards and industry codes and standards. (Note: Different codes and standards may use different terminology for relief; e.g., for building code applications, the terms 'modification' or 'alternative' may be substituted for 'equivalency'.)

(3) Equivalency. In accordance with the responsibilities and authorities assigned by Executive Order (E.O.) 12344, *Naval Nuclear Propulsion Program,* codified in 50 United States Code (U.S.C.) sections 2406 and 2511, and to ensure consistency through the joint Navy/DOE Naval Nuclear Propulsion Program, the Deputy Administrator for Naval Reactors (Director) will implement and oversee requirements and

practices pertaining to this Directive for activities under the Director's cognizance, as deemed appropriate.

(4) Exemption. This Order does not apply to activities that are regulated by the Nuclear Regulatory Commission (NRC) or a state under an agreement with the NRC, including activities certified by the NRC under Section 1701 of Pub. L. 83-703, *Atomic Energy Act of 1954*, as amended. DOE orders, regulations, technical standards, and/or guidelines will apply to activities where the NRC does not exercise regulatory authority or by agreement with NRC.

(5) Exemption. This Order does not apply to transportation activities that are regulated by the Department of Transportation.

(6) Exemption. The following portions of this Order do not apply to accelerator facilities that are covered by DOE O 420.2C, *Safety of Accelerator Facilities*: (1) nuclear safety design requirements, and (2) system engineer program requirements.

(7) Exemption. Specific, individual requirements of this Order do not apply to Nuclear Explosive and Weapons Surety Program activities, including transportation activities, for the prevention of nuclear detonations if application of such specific requirements would compromise the safety and effectiveness of these activities. In the event of such conflicts between specific requirements of this Order and those of DOE O 452.1E, *Nuclear Explosive and Weapon Surety Program*, or DOE O 452.2E, *Nuclear Explosive Safety*, the related requirements of these latter weapons and explosives safety directives take precedence.

(8) Exemption. This Order does not apply to the Bonneville Power Administration, in accordance with Secretarial Delegation Order Number 00-033.00C to the Bonneville Power Administrator and Chief Executive Officer.

(9) Exemption. The design requirements in this Order do not apply to projects that have reached a high level of design maturity, as determined by the appropriate Head of Departmental Element. Examples of projects that have reached a high level of design maturity include projects that have completed the Critical Decision (CD)-2 milestone or those projects that have completed the CD-1 milestone with a high level of design maturity. This exemption is provided to control project costs; new design requirements in this Order may be considered for inclusion where they provide significant benefits and/or net cost savings.

(10) Exemption. This Order does not apply to off-site office facilities that are owned or leased by the General Services Administration.

d. Government-Owned, Government-Operated Facilities. The CRD (see Attachment 1 of this Order) sets forth requirements that must also be applied to DOE government-owned, government-operated facilities. Government operators must comply with the requirements in the CRD, as set forth in Attachment 1 of this Order.

4. REQUIREMENTS. DOE Elements must:

a. Approve and oversee contractor programs, as specified in Section 5 of this Order.

b. Implement the requirements in Attachment 1 of this Order for government-owned government-operated facilities.

c. Provide oversight of the contractor CSE program and the operability of safety systems under the purview of the CSE program.

d. Document any operational responsibilities that are assigned to the contractor regarding the Authority Having Jurisdiction (AHJ) for matters involving fire protection as defined by the National Fire Protection Association (NFPA) codes.

e. Document any authorities associated with the building code official, as defined in DOE-STD-1066-2016, *Fire Protection*, that are assigned to the contractor.

f. Establish an integrated site-wide wildland fire management plan, consistent with the relevant portions of the *Federal Wildland Fire Management Policy.*

g. Direct its contractors, as applicable, to use DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, for preparing documented safety analyses (DSAs), when the DOE-STD-3009 method is used to satisfy 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*, requirements for new DOE non-reactor nuclear facilities and major modifications[1] to existing DOE non-reactor nuclear facilities. The appropriate Head of Departmental Element, or designee, with concurrence by the applicable Central Technical Authority, may approve use of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chg. Notice 3, for major modifications to existing non-reactor nuclear facilities, with the condition that the approach to chemical safety and worker safety is consistent with that described in Appendices B and C of DOE-STD-1189-2008, *Integration of Safety into the Design Process*.

h. Direct its contractors, as applicable, to carry out the analysis prescribed in Section 3.3.1 of DOE-STD-3009-2014 pertaining to "Existing Facilities with Mitigated Offsite Consequence Estimates over the EG," and include the results of

[1] 10 CFR 830.3 defines major modification as follows: "Major modification means a modification to a DOE nuclear facility that is completed on or after April 9, 2001 that substantially changes the existing safety basis for the facility." DOE-STD-1189-2016, *Integration of Safety into the Design Process,* provides a process to use to identify major modifications and examples of major modifications.

this analysis in applicable DSAs for existing DOE nuclear facilities and activities, whenever the safety analysis concludes that the mitigated off-site dose consequences for one or more accident scenarios exceed the Evaluation Guideline of 25 rem.

i. Review and approve safety basis and safety design basis documents in accordance with DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*.

5. RESPONSIBILITIES.

a. Heads of Departmental Elements, and Administrator, National Nuclear Security Administration.

(1) Ensure that the requirements of this Order and the CRD are implemented for facilities, activities, or programs under their cognizance. Review and, where justified, approve requests for equivalencies and exemptions to the requirements of this Order, processed in accordance with DOE O 251.1D.

(2) In accordance with Section 3.c.(1) of this Order, approve the basis for not including multiple physical barriers to prevent or mitigate the unintended release of radioactive materials to the environment, as part of the hazard category 1, 2, and 3 nuclear facility designs, where justified by sound technical basis.

(3) Review and approve safety basis and safety design basis documents in accordance with DOE-STD-1104-2016.

b. Associate Under Secretary, Office of Environment, Health, Safety and Security.

(1) Develops and maintains policy, requirements, guidance, and technical standards relating to this Order and the CRD.

(2) Provides technical advice and assistance on the implementation of policy, requirements, guidance, and technical standards related to this Order and the CRD.

(3) Provides comments on requests for exemptions from requirements of this Order.

c. Director, Office of Enterprise Assessments.

Plans and conducts independent oversight reviews of implementation of the requirements of this Order and the CRD (see DOE O 226.1B, *Implementation of Department of Energy Oversight Policy*, and DOE O 227.1A, *Independent Oversight Program*, for details).

d. Heads of Field Elements.

(1) Ensure that the facilities, activities, and programs under their purview operate in compliance with the requirements of this Order and the CRD.

(2) Identify contracts to which the CRD applies and notify contracting officers when contracts are affected by this Order.

(3) Review and, where justified, approve equivalencies to DOE technical standards and industry codes and standards determined to be applicable to the facility design or operations.

(4) Approve contractor emergency services organization baseline needs assessments (BNAs) that meet the requirements in Attachment 2, Chapter II, Section 3.e.(1) of this Order.

(5) Approve contractor fire protection programs (this may be accomplished in conjunction with 10 CFR Part 851, *Worker Health and Safety Program*) and Wildland Fire Management Plans.

(6) Fulfill the roles and responsibilities for the AHJ for matters involving fire protection, as defined by the NFPA, including documentation of any delegation or assignment of related responsibilities (See Section 5.2.4 of DOE-STD-1066-2016, for further discussion of delegations).

(7) Fulfill the roles and responsibilities for the building code official, as defined in DOE-STD-1066-2016, including documentation of any delegation or assignment of related responsibilities.

(8) Perform responsibilities of 'owner,' or other equivalent term in the application of DOE technical standards or industry codes and standards, including documentation of any delegation or assignment of related responsibilities.

(9) Approve contractor's criticality safety program documentation, ensure that it meets requirements in Chapter III of Attachment 2 of this Order. (This may be accomplished through the safety basis documentation approval process.)

(10) Approve periodic NPH assessment evaluations, any recommended update actions, and any recommended upgrade plans, in accordance with Chapter IV of Attachment 2 of this Order.

(11) Provide oversight for contractor CSE programs and the operability of associated safety systems.

(12) Consistent with DOE O 226.1B, establish and implement an appropriate self-assessment and oversight program for the elements of this Order.

(13) When delegated, review and approve safety basis and safety design basis documents in accordance with DOE-STD-1104-2016.

e. Contracting Officers.

Incorporate the CRD, or its requirements, into affected contracts and procurement requests in a timely manner when notified.

f. Central Technical Authorities.

(1) Review and, where justified, concur on requests for equivalencies and exemptions to the requirements of this Order, processed in accordance with DOE O 251.1D.

(2) Provide support, as requested by the DOE Heads of Field Element, on review of equivalencies to DOE technical standards and industry codes and standards determined to be applicable to the facility design or operations.

6. INVOKED STANDARDS. The following DOE technical standards and industry standards are invoked as required methods in this Order in accordance with the applicability and conditions described within this Order. Any technical standard or industry standard that is mentioned in or referenced by this Order, but is not included in the list below, is not invoked by this Order. Note: DOE O 251.1D, Appendix J provides a definition for "invoked technical standard."

a. DOE Standard (STD)-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*. This DOE technical standard is required to be used for specified new non-reactor hazard category 1, 2, and 3 nuclear facilities and major modifications to hazard category 1, 2, and 3 non-reactor nuclear facilities. In addition, Section 3.3.1 of this technical standard is required to be used for existing DOE nuclear facilities that have mitigated off-site dose estimates greater than 25 rem. See Section 4 and Attachment 1 for specific requirements.

b. DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*. This DOE technical standard is required to be used by DOE personnel for review and approval of safety basis and safety design basis documents. See Section 4 for specific requirements.

c. DOE-STD-1189-2016, *Integration of Safety into the Design Process*. This DOE technical standard is required to be used for development and integration of safety analysis and supporting design for new hazard category 1, 2, and 3 nuclear facilities and major modifications to existing hazard category 1, 2 and 3 nuclear facilities. See Attachment 2, Chapter I for specific requirements.

d. DOE-STD-3007-2017, *Preparing Criticality Safety Evaluations at DOE Nonreactor Nuclear Facilities*. This DOE technical standard is required to be

used for conduct of criticality safety evaluations at DOE facilities and activities with the potential for inadvertent criticalities, unless another documented method is approved by DOE. See Attachment 2, Chapter III for specific requirements.

e. DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*. This DOE technical standard is required to be used for developing the design of new facilities and major modifications. See Attachment 2, Chapter IV for specific requirements.

f. American National Standards Institute (ANSI)/American Nuclear Society (ANS)-8 Nuclear Criticality Safety Standards. This set of industry standards is required to be satisfied by Criticality Safety Programs for facilities and activities with the potential for inadvertent criticalities, unless otherwise modified and approved by DOE. See Attachment 2, Chapter III for specific requirements.

g. Institute of Electrical and Electronics Engineers (IEEE) 379-2014, *IEEE Standard for Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems*. This industry standard is required to be applied to the design of safety-class structures, systems, and components (SSCs) for new nuclear facilities and major modifications, unless another applicable standard is approved by DOE. See Attachment 3 for specific requirements.

h. IEEE 323-2003 (R2008), *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations*. This industry standard is required to be used to ensure environmental qualifications of safety-class SSCs for new nuclear facilities and major modifications, unless another applicable standard is approved by DOE. See Attachment 3 for specific requirements.

i. IEEE 384-2008, *IEEE Standard Criteria for Independence of Class IE Equipment and Circuits*. This industry standard is required to be used for new nuclear facilities and major modifications for physical and electrical separation methods, including the use of separation distance, barriers, electrical isolation devices, or any combination thereof, unless another applicable standard is approved by DOE. See Attachment 3 for specific requirements.

7. APPLICABLE STANDARDS. An applicable DOE technical standard or industry code or standard is one for which it has been determined by the contractor that it will be used or will be applied for a specific facility/site to meet the design, construction, and operational requirements described in this Order. This Order provides the process for determining which standards will be applicable (as described in the Attachments to this Order). DOE approves the contractor's list of applicable DOE technical standards or industry codes or standards via different means, including approval of safety design documents, the fire protection program, and inclusion of the DOE technical standards or industry codes or standards in the contract.

Once a standard is identified as applicable, this Order requires that the applicable requirements of the applicable standards be followed unless relief is obtained. The

provisions for relief (exemptions and equivalencies) for applicable standards are different than the relief provisions for invoked standards, and are described in Section 3.c and Attachment 1, Section 2. Together, the invoked standards, the applicable standards, and any other applicable DOE requirement documents, along with any exemptions and equivalencies, make up the "Code of Record" for a given project or design, and reflect DOE's commitment to standard-based safety management.

8. REFERENCES AND ACRONYMS. References and acronyms can be found in Attachment 4 of this Order.

9. CONTACT. Address inquiries to the Office of Environment, Health, Safety and Security; Office of Nuclear Safety, 301-903-3331.

BY ORDER OF THE SECRETARY OF ENERGY:

DAN R. BROUILLETTE
Deputy Secretary

CONTRACTOR REQUIREMENTS DOCUMENT
DOE O 420.1C, *FACILITY SAFETY*

This Contractor Requirements Document (CRD) includes requirements outlined in Attachments 2 and 3 of Department of Energy (DOE) Order (O) 420.1C, *Facility Safety*, referenced in and made a part of this CRD, and which provide program requirements and/or information applicable to contracts in which this CRD is inserted.

1. GENERAL REQUIREMENTS.

   a. This CRD establishes facility safety requirements for design, construction, operation, management, decontamination, decommissioning, and demolition of DOE sites or facilities. Regardless of the performer of the work, the contractors are responsible for complying with the requirements of this CRD. The contractors are responsible for flowing down the requirements of this CRD to subcontractors at any tier, to the extent necessary, to ensure the contractors' compliance with the requirements.

   b. Contractors must satisfy the requirements set forth in Attachments 2 and 3 of DOE O 420.1C.

   c. For design and construction activities, contractors must identify the applicable industry codes and standards, including the *International Building Code* (IBC), and the applicable DOE requirements and technical standards. If approved by the responsible DOE Head of the Field Element, state, regional, and local building codes may be used in lieu of the IBC upon contractor submission of documentation providing a basis that demonstrates that implementation of the substituted code for the specific application will meet or exceed the level of protection that would have been provided by the IBC. Additionally, DOE O 413.3B Chg. 5, *Program and Project Management for the Acquisition of Capital Assets*, requires nuclear projects to establish and maintain a Code of Record (COR) early in project design for identifying applicable industry codes and standards. For leased facilities that are not nuclear hazard category 1, 2, or 3 facilities, the requirements of this paragraph apply to the extent determined by the DOE Head of Field Element.

   d. Contractors must satisfy the requirements (i.e., mandatory statements) in DOE technical standards and industry codes and standards that are identified as applicable in accordance with Section 1.c. above, unless relief is approved in accordance with Section 2, below.

   e. When the DOE-STD-3009 methodology is used to satisfy 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*, contractors must prepare Documented Safety Analyses (DSAs) in accordance with DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, for new DOE non-reactor nuclear facilities and major modifications to existing DOE non-reactor nuclear facilities. Note: for such major modifications

to existing non-reactor nuclear facilities, the appropriate Head of Departmental Element, with concurrence by the applicable Central Technical Authority, may approve use of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chg. Notice 3.

f. Contractors must carry out the analysis prescribed in Section 3.3.1 of DOE-STD-3009-2014 and include the results of this analysis in applicable DSAs for existing DOE nuclear facilities and activities whenever the safety analysis concludes that the mitigated off-site dose consequences for one or more accident scenarios exceed the Evaluation Guideline of 25 rem.

2. RELIEF FROM REQUIREMENTS, CODES AND STANDARDS.

a. Requests for equivalencies and exemptions to the requirements of this attachment are processed in accordance with DOE O 251.1D, Departmental Directives Program. For such equivalencies and exemptions, DOE O 251.1D requires approval, in consultation with the Office of Primary Interest, by the responsible Head of Departmental Element or designee, or in the case of NNSA, by the Administrator or designee. Because this Order affects nuclear safety, requests for advice from the Office of Primary Interest (i.e., Office of Nuclear Safety) on proposed equivalencies and exemptions for nuclear facilities should allow 45 days, in accordance with DOE O 251.1D. Requests for equivalencies and exemptions to the requirements of this attachment must be provided to the responsible contracting officer to facilitate DOE review. (Note: The requirements in this paragraph also address the requirements of this attachment, and those in Attachments 2 and 3, that relate to DOE technical standards and industry codes and standards that are invoked as required methods.)

b. Equivalencies to DOE technical standards and industry codes and standards determined to be applicable to the facility design or operations must demonstrate an equivalent level of safety (i.e., meets or exceeds the level of protection) and be approved by the DOE Head of Field Element or designee.

3. REFERENCES AND ACRONYMS. Attachment 4 of DOE O 420.1C provides a list of references and acronyms. Reference documents that may be helpful in implementing this Order include rules, directives, guidance, DOE technical standards, and industry codes and standards.

FACILITY SAFETY REQUIREMENTS

This attachment provides information and/or requirements associated with the Department of Energy (DOE) Order (O) 420.1C, *Facility Safety*, as well as information and/or requirements applicable to contracts into which the associated Contractor Requirements Document (CRD), (see Attachment 1 of DOE O 420.1C) is inserted.

CHAPTER I. NUCLEAR SAFETY DESIGN CRITERIA

1. OBJECTIVE. To establish requirements for safety design of DOE hazard category 1, 2, and 3 nuclear facilities to support implementation of DOE Policy (P) 420.1, *Department of Energy Nuclear Safety Policy*.[2]

   The requirements of this chapter (and the criteria in Attachment 3 of DOE O 420.1C) support implementation of the requirements for hazard category 1, 2, and 3 nuclear facilities in 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*, Subpart B, Safety Basis Requirements.

2. APPLICABILITY.

   a. This chapter applies to the design and construction of:

      (1) new hazard category 1, 2, and 3 nuclear facilities, as defined by 10 CFR Part 830; and

      (2) major modifications to hazard category 1, 2, and 3 nuclear facilities, as defined in 10 CFR Part 830, that could substantially change the facility safety basis (Note: See DOE Standard (STD)-1189-2016, *Integration of Safety into the Design Process*, for criteria and discussion on major modifications).

   b. This chapter does not impose requirements on existing facilities, except for major modifications[3] to those facilities. The requirements of this chapter may be used to develop comparisons of existing facilities to the requirements for new facilities, as one aide to judgment when evaluating the costs and benefits of non-mandatory upgrades to existing facilities.

   c. Except for the requirements of Section 3.b.(3), this chapter does not apply to nuclear deactivation or decontamination and decommissioning activities at end-of-facility-life if the safety analysis demonstrates that adequate protection is provided consistent with the requirements of 10 CFR Part 830 through alternate means and it is not cost beneficial to apply the provisions of this chapter for the limited remaining life of the activity.

3. REQUIREMENTS.

   a. Integration of Safety with Design.

      (1) Safety analysis and supporting design must be developed and integrated in accordance with DOE-STD-1189-2016.

---

[2] DOE's nuclear safety policy (DOE P 420.1, *Department of Energy Nuclear Safety Policy*) is to design, construct, operate, and decommission its nuclear facilities in a manner that ensures adequate protection of workers, the public, and the environment.

[3] DOE-STD-1189-2016, *Integration of Safety into the Design Process,* provides a definition and examples of major modifications.

(2) Safety analyses must be used to:

(a) identify safety class and safety significant structures, systems, and components (SSCs) needed to fulfill the safety functions in order to prevent and/or mitigate design basis accidents (DBAs), including natural and man-induced hazards and events;

(b) identify the safety functional requirements of the safety class and safety significant SSCs; and

(c) identify specific administrative controls (SACs) needed to fulfill safety functions. (Note: See DOE-STD-1186-2016, Specific Administrative Controls).

b. Nuclear Facility Design.

(1) The nuclear facility design must include multiple layers of protection (as part of the design defense-in-depth) to prevent or mitigate the unintended release of radioactive materials into the environment.

(2) Defense-in-depth must include all of the following:

(a) choosing an appropriate site;

(b) minimizing the quantity of material-at-risk;

(c) applying conservative design margins;

(d) applying quality assurance;

(e) using successive/multiple physical barriers for protection against radioactive releases (Note: If an exemption to having multiple barriers is required, it is the responsibility of the Head of Departmental Element to approve, or disapprove, the exemption for not including multiple physical barriers);

(f) using multiple means to ensure safety functions are met by—

1 controlling processes;

2 maintaining processes in safe status;

3 providing preventive and/or mitigative controls for accidents with the potential for radiological releases; and

4 providing means for monitoring facility conditions to support recovery from upset or accident conditions;

5 using equipment in combination with administrative controls that—

a restrict deviation from normal operations;

b monitor facility conditions during and after an event; and

c provide for response to accidents to achieve a safe condition;

6 providing means to monitor accident releases as required for emergency response (see DOE O 151.1D, *Comprehensive Emergency Management System,* for detailed requirements); and

7 establishing emergency plans for minimizing the effects of an accident (see DOE O 151.1D for detailed requirements).

(3) Hazard category 1, 2, and 3 nuclear facilities with uncontained radioactive materials (as opposed to materials determined by safety analyses to be adequately contained within qualified 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 and during and following accidents, up to and including DBAs. Confinement design must include the following:

(a) For a specific nuclear facility, the number, arrangement, and characteristics of confinement barriers as determined on a case-by case basis.

(b) The type, quantity, form, and conditions for dispersing the radioactive material in the confinement system design.

(c) An active confinement ventilation system as the preferred design approach for nuclear facilities with potential for radiological release.[4] Alternate confinement approaches may be acceptable if a technical evaluation demonstrates either that the alternate confinement approach results in very high assurance of the confinement of radioactive materials or that an active confinement system provides no benefits.

Guidance for confinement ventilation systems and evaluation of the alternatives is provided in DOE Guide (G) 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use with DOE O 420.1C, Facility Safety*. Some facilities where the only

[4] The safety classification (if any) of the ventilation system is determined by the facility DSA.

radioactive hazard/material is tritium have determined there is no benefit from an active confinement ventilation system.

(4) Hazard category 1, 2, and 3 nuclear facilities must be designed to:

(a) facilitate safe deactivation, decommissioning, decontamination, and demolition at the end of facility life, including incorporation of design considerations during the operational period that facilitate future decontamination and decommissioning;

(b) facilitate inspections, testing, maintenance, repair, and replacement of safety SSCs as part of a reliability, maintainability, and availability program with the objective of maintaining the facility in a safe state;

(c) keep occupational radiation exposures within regulatory limits, and as low as reasonably achievable; and

(d) provide hazard controls for prevention and mitigation of hazardous material releases and for defense in depth, consistent with the hierarchy described in DOE-STD-1189-2016.

(5) Facility process systems must be designed to minimize waste production and mixing of radioactive and non-radioactive wastes.

(6) Safety SSCs and safety software must be designed to perform their safety functions when called upon.

(7) Active safety class systems must be designed to meet single failure[5] criterion.

(8) DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Criteria for Use with DOE O 420.1C, Facility Safety,* provides an acceptable method to meet the requirements stated in this chapter.

(9) Critical experiments facilities must be designed and operated in accordance with applicable American National Standards Institute (ANSI) and the American Nuclear Society (ANS) standards. ANSI/ANS-1-2000 (R2012), *Conduct of Critical Experiments*, and ANSI/ANS-14.1-2004 (R2014), *Operation of Fast Pulse Reactors*, are two such standards that may be applicable.

[5] IEEE 379-2014, *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems*, provides a definition of the single failure criterion. ANS 58.9-2002 (R2009), *Single Failure Criteria for Light Water Reactor Safety-Related Fluid Systems*, provides additional guidance for single failure criteria for mechanical systems.

(10) Facility design must also be integrated with other design requirements, as applicable, including explosive safety, industrial safety, and nuclear explosive safety (if applicable).

CHAPTER II. FIRE PROTECTION

1. OBJECTIVE. To establish requirements for comprehensive fire protection programs for DOE facilities and emergency response organizations to:

   a. Minimize the likelihood of occurrence of a fire-related event;

   b. Minimize the consequence of a fire-related event affecting the public, workers, environment, property and missions; and

   c. Provide a level of safety protection consistent with the "highly protected risk" class of industrial risks.

2. APPLICABILITY. This chapter applies to organizations that have responsibility for the design, construction, maintenance, or operation of government-owned or government-leased facilities and contractor-leased facilities used for DOE mission purposes. For leased facilities that are not nuclear hazard category 1, 2, or 3 facilities, the requirements of this chapter apply to the extent determined by the DOE Head of Field Element. (Note: DOE-STD-1066-2016, *Fire Protection*, provides guidance on a graded approach to fire protection for leased facilities.)

3. REQUIREMENTS.

   a. General Fire Protection Program Requirements.

      (1) Policy Statement. A policy must be established that affirms the contractor's commitment to provide a comprehensive fire protection and emergency response program that meets the requirements of this chapter, related DOE directives, and other applicable requirements.

      (2) Codes and Standards. The codes and standards determined to be applicable, including DOE technical standards, the building code, National Fire Protection Association (NFPA) codes and standards, and other industry codes and standards, must be identified in the fire protection and emergency response programs. The fire protection and emergency response programs may specify provisions for relief (exemptions and equivalencies) from identified, applicable fire protection codes and standards; otherwise, see Attachment 1, Section 2 for relief provisions.

         (a) Facilities, and major modifications thereto, must be constructed to meet applicable codes and standards that are in effect when design criteria are approved (otherwise known as the Code of Record, or COR). Other facility changes must meet the most recent applicable codes and standards to the extent determined by the Authority Having Jurisdiction (AHJ).

(b) Provisions of subsequent editions of codes or standards (promulgated after the COR is established) are mandatory only to the extent that they are explicitly stated to be applicable to existing facilities.

(c) Conflicts between DOE O 420.1C; NFPA codes and standards; and the applicable building code must be resolved as follows:

1 Requirements of DOE O 420.1C take precedence over all NFPA and building code requirements and are subject to the relief requirements of DOE O 420.1C.

2 Conflicts between NFPA requirements and the applicable building code requirements are resolved by the DOE Head of Field Element, consistent with DOE-STD-1066-2016, and in consultation with designated building code and fire protection subject matter experts.

b. Fire Protection Program Administration.

(1) Documentation. A documented fire protection program that includes the elements and requirements identified in this chapter for design; operations; emergency response; fire analysis and assessments; wildland fire; and specific fire protection program criteria must be developed, implemented, and maintained by the contractor. Contractor must submit this documented fire protection program to the DOE Head of Field Element for review and approval (Note: this may be accomplished in conjunction with submittals required by 10 CFR Part 851, *Worker, Health and Safety Program*).

(2) Fire Protection Methods. Fire Protection Programs must describe the methods used to implement the requirements of this chapter. DOE-STD-1066-2016 is the applicable fire protection standard for use at DOE facilities. [Note: Relief provisions for applicable fire protection standards are described in Section 3.a.(2) above.]

(3) Self-Assessments. A documented comprehensive self-assessment of the fire protection program must be performed at least every three years, or at a frequency with appropriate justification approved by the DOE Head of Field Element.

c. Design.

(1) Design Process. A process must be established to ensure that fire protection program requirements are documented and incorporated into plans and specifications for design of new facilities and modifications to existing facilities.

(2) Protection Thresholds[6].

(a) New facilities (non-relocatable) exceeding 5,000 sq. ft. of floor area must be of Type I or Type II construction, as defined in the applicable building codes.

(b) Automatic fire suppression systems must be provided throughout new facilities exceeding 5,000 sq. ft. of floor area or where a Maximum Possible Fire Loss (MPFL) exceeds $5.9 million (in 2018 dollars[7]), unless a specific provision of an applicable NFPA code provides different criteria for coverage (such as elimination of sprinklers from a small closet).

(c) Automatic fire suppression systems must be provided throughout facilities in which any of the following conditions exist:

1 where required by safety basis document (for example, to prevent loss of safety functions or provide defense-in-depth);

2 significant life safety hazards;

3 where fire may cause unacceptable mission or program interruption if automatic fire suppression systems are not provided;

4 where a modification to an existing facility would cause the MPFL to exceed $5.9 million (in 2018 dollars) for the facility; or

5 where a modification to an existing facility results in facility floor area that exceeds 5,000 sq. ft.

(d) For property protection, multiple fire protection approaches, such as a fire suppression system and a fire detection and alarm system, must be provided in areas where the MPFL exceeds $177 million (in 2018 dollars) (refer to DOE-STD-1066-2016).

(e) For property protection, fire areas must be established such that the MPFL for each fire area does not exceed $412 million (in 2018

[6] Some of the requirements in this section on protection thresholds may not apply to portions of subterranean facilities that otherwise meet the requirements in Appendix D of DOE-STD-1066-2016.

[7] DOE G 413.3-21 Chg. 1, *Cost Estimating Guide*, Section 6.4.4 provides guidance on historical cost estimates and historical cost indexes. To convert 2018 dollar amounts to present value, an applicable historical cost index is selected, documented, and used, as described in DOE G 413.3-21.

dollars). Fire walls or other separation approaches may be used to meet this requirement.

(3) Fire Protection and Life Safety Systems.

(a) Fire Suppression. The inadvertent operation or failure of fire suppression systems must not result in the loss of function of safety class or safety significant systems. (Note: This requirement addresses proper design of the fire suppression system to ensure it does not impact safety systems and is not intended to drive need for redundancy in safety significant system design.)

(b) Fire Barriers. Complete fire-rated construction and barriers, commensurate with the applicable codes and/or safety basis requirements, must be provided to isolate hazardous areas and minimize fire spread and loss potential consistent with limits as established in this chapter. Fire barrier locations and construction must be documented.

(c) Fire Detection. Automatic fire detection must be provided to the extent required by applicable industry codes and standards.

(d) Life Safety. Requirements for life safety and means of egress are provided in 10 CFR Part 851. Other codes and standards, such as the *International Building Code* (IBC), and NFPA 101, *Life Safety Code,* may also be applicable.

(e) Water Supply and Distribution. A reliable and adequate water supply and distribution system must be provided for fire suppression, as documented through appropriate analysis.

(f) Emergency Notification. A means to notify responders and building occupants of a fire must be provided (e.g., fire alarm signaling system and/or site-wide mass notification capabilities for major incidents affecting the site).

(4) Special Hazards. Fire protection systems or features, and appropriate procedures to address fire and related hazards that are special or unique to DOE and not addressed by industry codes and standards, must be established.

d. Operations.

(1) Criteria and Procedures. Comprehensive, written fire protection criteria and procedures must be established to implement the fire protection program requirements that include:

(a) site-specific requirements;

(b) staff organization, resources, training, and roles and responsibilities;

(c) inspection, testing, and maintenance of fire protection systems;

(d) use and storage of combustible, flammable, radioactive, and hazardous materials;

(e) a "hot-work" control program;

(f) identification and tracking of fire protection system impairments;

(g) fire prevention measures (e.g., reduced combustible loading, hot-work procedures, ignition source controls);

(h) facility and Fire Hazards Analysis (FHA) assessment programs;

(i) design and construction oversight; and

(j) equivalencies, exemptions, modifications, and variances processes.

(2) Implementation. To ensure effective implementation of these requirements, the following elements must be addressed.

(a) Staffing. The contractor must ensure it has access to qualified, trained fire protection staff (that includes fire protection engineers (FPEs), technicians, and firefighting personnel) needed to implement the requirements of this chapter.

(b) Design Review. Documented review of plans, specifications, procedures, and acceptance tests must be conducted by an FPE (Note: A definition for FPE is provided in DOE-STD-1066-2016). A process must be established to oversee fire protection-related activities from conceptual design to final acceptance.

(c) Equivalencies and Exemptions. A process must be established for developing and requesting AHJ approval of fire protection equivalencies and exemptions to fire protection requirements. Records of technical justification must be maintained and reevaluated for appropriateness as activities or operations change.

(d) Assigned Authority. If assigned, the contractor must document the level of authority to execute the duties and responsibilities of the AHJ, in accordance with the contractor's overall fire protection and emergency response programs.

e. Emergency Response. Provide emergency response capabilities, as necessary, to meet site needs as established by the baseline needs assessment (BNA), safety basis requirements, and applicable regulations, codes and standards.

(1) Baseline Needs Assessment. A BNA of the fire protection and emergency response organization must be conducted, and the BNA must:

(a) establish capabilities to provide:

1 effective response to extinguish fires;

2 emergency medical, rescue and hazardous materials response; and

3 staffing, apparatus, facilities, equipment, training, pre-incident plans, mutual aid, and procedures.

(b) reflect applicable requirements of NFPA codes and standards, and DOE direction;

(c) be submitted to the DOE Head of Field Element for approval;

(d) be reviewed at least every three years, or whenever a significant new hazard that is not covered by the current BNA is introduced, and be updated as appropriate (Note: If no update is necessary, this result must be documented following the review) and submitted to the DOE Head of Field Element for approval; and,

(e) be incorporated into site emergency plans, FHAs, and safety basis documentation.

(2) Pre-Incident Plans. Pre-incident strategies, plans, and standard operating procedures must be established to enhance the effectiveness of manual fire suppression activities, including areas within or adjacent to, moderator-controlled areas. The criticality safety staff must review pre-incident plans and procedures related to moderator-controlled areas.

(3) Manual Fire Suppression Activities.

(a) Physical access and appropriate equipment that is accessible for effective manual firefighting intervention must be provided.

(b) Procedures governing the use of fire-fighting water or other neutron moderating materials to suppress fire within, or adjacent to, moderation controlled areas must be established and reviewed by a criticality subject matter expert prior to release.

(c) Procedures governing firefighting techniques to be used during deactivation, decontamination, and demolition phases must be established, when applicable.

(d) Where no alternative exists to criticality safety restrictions on the use of water for fire suppression, the need for such restrictions must be fully documented with written technical justification.

f. Fire Hazard Analyses and Facility Assessments.

(1) Fire Hazards Analyses. FHAs, using a graded approach, must be conducted for the following cases:

(a) all hazard category 1, 2, and 3 nuclear facilities and major modifications thereto;

(b) facilities that represent unique fire safety risks;

(c) new facilities or modifications to existing facilities with value greater than $177 million (in 2018 dollars); and

(d) when directed by the responsible DOE authority. The FHAs must be:

1 performed under the direction of an FPE;

2 reviewed every three years by an FPE and revised as appropriate (Note: If no revision is necessary, this result must be documented following the review);

3 revised when−

a changes to the facility structure or layout, processes, occupancy, safety basis documentation, or BNA impacts the analysis in the FHA;

b a modification to an associated facility or process adds a significant new fire safety risk; or,

c the periodic (three-year) review identifies the need for changes; and

d integrated into safety basis documentation.

(2) Facility Assessments. Fire protection assessments must be conducted:

(e) annually, or at a frequency with appropriate justification approved by the DOE Head of Field Element, for facilities with a

replacement value in excess of $118 million (in 2018 dollars), facilities considered a high hazard, or those in which vital programs are involved, as defined by the responsible DOE authority; and,

(f) at least every three years, or at a frequency with appropriate justification approved by the DOE Head of Field Element, for remaining low and ordinary hazard facilities.

g. Wildland Fire. An integrated site-wide wildland fire management plan, consistent with the *Federal Wildland Fire Management Policy*, must be developed, provided to DOE Head of Field Element for approval, and implemented in accordance with the relevant portions of the NFPA 1143, *Standard for Wildland Fire Management*.

CHAPTER III. NUCLEAR CRITICALITY SAFETY

1. OBJECTIVE. To establish requirements for developing and implementing nuclear criticality safety programs (CSPs) for nuclear facilities and activities, including materials transportation activities, which provide adequate protection to the public, workers, and the environment.

2. APPLICABILITY. This chapter is applicable to DOE elements and DOE contractors with responsibility for nuclear facilities and activities that involve or will potentially involve radionuclides in such quantities that are equal to or greater than the single parameter limits for fissionable materials listed in ANSI/ANS-8.1-2014, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, and ANSI/ANS-8.15-2014, *Nuclear Criticality Safety Control of Selected Actinide Nuclides*. These limits must be adjusted where process conditions could credibly involve moderators or reflectors that are more effective than light water.

3. REQUIREMENTS.

   a. A CSP document must be developed and maintained that describes how the contractor will implement the requirements in this chapter, including the standards invoked by this chapter.

   b. The CSP document must describe how the contractor will satisfy the requirements of the ANSI/ANS-8 series of nuclear criticality safety standards that are in effect as of the date this Order, unless otherwise modified and approved by the DOE Head of Field Element. The CSP document must include an explanation as to why any recommendation in applicable ANSI/ANS-8 standards is not implemented.

   c. The CSP document must be submitted to and approved by the DOE Head of Field Element.

   d. Criticality safety evaluations must be conducted in accordance with DOE-STD-3007-2017, *Preparing Criticality Safety Evaluations at DOE Nonreactor Nuclear Facilities*, or by other documented methods approved by the DOE Head of Field Element.

   e. Fissile Material Accumulation Control. Facilities that conduct operations using fissionable material in a form that could inadvertently accumulate in significant quantities must include procedures for detecting and characterizing accumulations. The following national standards provide relevant guidance for procedure development: ASTM C1455-14e1, *Standard Test Method for Nondestructive Assay of Special Nuclear Material Holdup Using Gamma-Ray Spectroscopic Methods*, and any other nondestructive assay consensus or DOE standards applicable to the measurement technique selected.

f. Criticality safety evaluations must show that entire processes involving fissionable materials will remain subcritical under normal and credible abnormal conditions, including those initiated by design basis events.

g. The criteria and process for developing the guidelines for firefighting in areas within or adjacent to moderator-controlled areas must be coordinated with firefighting pre-incident plans and procedures.

CHAPTER IV. NATURAL PHENOMENA HAZARDS MITIGATION

1. OBJECTIVE. To establish requirements for DOE facility design, construction, and operations to protect the public, workers, and the environment from the impact of natural phenomena hazards (NPH) events (e.g., earthquake, wind, flood, lightning, snow, and volcanic eruption).

2. APPLICABILITY. Requirements in this chapter apply to all government-owned and government-leased nuclear and nonnuclear facilities and sites. Design requirements (Sections 3.a, 3.b, and 3.c, below) apply to new facilities, major modifications, and modifications that may be warranted based on periodic NPH assessment and upgrade requirements. For leased facilities that are not nuclear hazard category 1, 2, or 3 facilities, the requirements of this chapter apply to the extent determined by the DOE Head of Field Element.

3. REQUIREMENTS.

   a. General. Facilities must be designed, constructed, maintained, and operated to ensure that SSCs will be able to perform their intended safety functions effectively under the combined effects of NPH and normal loads defined in the applicable building codes contained in facilities' CORs. Nuclear facility safety functions that the SSCs must perform during and after an NPH event must be defined in the facility's safety basis documentation. Safety functions include:

      (1) confinement/containment of hazardous materials;

      (2) protection of occupants and co-located workers of the facility and the public;

      (3) continued operation of essential facilities and equipment;

      (4) safe shutdown of hazardous facilities and equipment; and

      (5) maintenance of personnel access to areas needed for responding to accidents during NPH events.

   b. NPH Design Criteria. The design of new facilities and major modifications must be developed in accordance with the applicable requirements and criteria contained in DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*. (Note: Requirements for non-nuclear facilities are described in Section 2.2 of DOE-STD-1020-2016.)

   c. NPH Accident Analysis. The NPH analysis supporting design and construction of facilities and safety SSCs must be documented and include evaluation of:

      (1) potential damage to and failure of safety SSCs resulting from both direct and indirect NPH events; and,

(2) 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.

d. Review and Upgrade Requirements for Existing DOE Nuclear Facilities (Hazard Category 1, 2 and 3).

(1) Existing facility or site NPH assessments must be reviewed at least once every ten years and whenever significant changes in NPH data, criteria, and assessment methods warrant updating the assessments. Section 9.2 of DOE-STD-1020-2016 contains criteria and guidance for performing these reviews. The review results, along with any recommended update actions, must be submitted to the DOE Head of Field Element for approval. If no update is necessary, this result must be documented following the review.

(2) If a new assessment of NPH indicates deficiencies in existing SSC design, a plan for upgrades must be developed and implemented on a prioritized schedule, based on the safety significance of the upgrades, time or funding constraints, and mission requirements. The upgrade plans must also be submitted to the DOE Head of Field Element for approval. Sections 9.3 and 9.4 of DOE-STD-1020-2016 contain guidance on performing upgrade evaluations.

e. Seismic Detection. DOE sites with nuclear or hazardous materials must have instrumentation or other means to detect and record the occurrence and severity of seismic events.

f. Post-Natural Phenomena Procedures. Facilities or sites with hazardous materials must have procedures for inspecting facilities for damage from severe NPH events and placing a facility into a safe configuration when damage has occurred.

CHAPTER V. COGNIZANT SYSTEM ENGINEER PROGRAM

1. OBJECTIVE. To establish requirements for a cognizant system engineer (CSE) program for hazard category 1, 2, and 3 nuclear facilities and to ensure continued operational readiness of the systems within its scope.

   A key element of the CSE program is the designation of CSEs who are responsible for maintaining overall cognizance of assigned systems; providing systems engineering support for operations and maintenance; and technical support of line management safety responsibilities for ensuring continued system operational readiness.

2. APPLICABILITY. Requirements of this chapter apply to all hazard category 1, 2, and 3 nuclear facilities that have attained operational status (such as achieving Critical Decision 4 (CD-4) per DOE O 413.3B, Chg. 5, *Program and Project Management for the Acquisition of Capital Assets*) and have:

   a. active safety class or safety significant SSCs, as defined in the facility's DOE-approved safety basis documentation; or

   b. other active systems that perform important defense-in-depth functions, as designated by facility line management.

   Note: This chapter does not apply to passive systems or design features. Facility management should consider establishing CSE programs before CD-4 to ensure their 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.

3. REQUIREMENTS.

   a. General. The protocols for implementing the site or facility CSE program must be documented, must include the functions, responsibilities, and authorities of CSEs, and must address the following elements:

      (1) Identification of systems covered by the CSE program and identification of systems assigned for coverage;

      (2) Configuration management;

      (3) Support for operations and maintenance; and

      (4) Training and qualifications of CSEs.

   b. CSE Program Coverage.

      (1) The CSE program must be applied to 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. The designated systems and the rationale for assignment of CSEs in a graded approach (see below) must be documented.

(2) A graded approach must be used in applying the requirements of the CSE program. The program must be tailored to facility hazards and the systems relied upon to prevent or mitigate those hazards, considering:

(a) Remaining Facility Lifetime and the Safety Significance of Remaining Operations. Facilities undergoing deactivation or decontamination/decommissioning may undergo frequent changes, modifications, or removal of systems no longer needed to support the safety basis of those operations. CSE programs may require more CSE attention in these operations than during normal operations. After deactivation, or when a facility is in long-term surveillance and maintenance, there may be less need for CSE attention.

(b) Safety Importance of the System. Not all systems are equal as measured by the likelihood and consequences of the hazard and the accidents that they prevent or mitigate. The level of system documentation detail in configuration management should be tailored to the importance of the system.

(3) A qualified CSE must be assigned to each active system within the scope of the program. Consistent with the graded approach, large, complex, or very important systems may require assignment of more than one CSE. Conversely, a single individual may be assigned to be the CSE for more than one system.

c. Configuration Management.

(1) A documented configuration management program must be established and implemented that ensures consistency among system requirements and performance criteria, system documentation, and physical configuration of the systems within the scope of the program. DOE-STD-1073-2016, Configuration Management, describes an acceptable methodology for establishing configuration management programs. The configuration management program must address:

(a) system design documentation;

(b) system assessments;

(c) control of maintenance;

(d) change control; and

(e) aging degradation and technical obsolescence.

(2) System design documents and supporting documents must be identified and kept current using formal change control and work control processes. DOE-STD-3024-2011, *Content of System Design Descriptions*, describes an acceptable methodology to achieve this function. Design documentation must include:

(a) system requirements and performance criteria essential to performance of the system's safety functions;

(b) the basis for system requirements; and

(c) a description of how the current system configuration satisfies the requirements and performance criteria.

(3) System assessments must include periodic reviews of system operability, reliability, and material condition. Reviews must assess the system for:

(a) the ability to perform design and safety functions;

(b) physical configuration as compared to system documentation; and

(c) system and component performance in comparison to established performance criteria.

(4) System maintenance and repair and modification must be controlled through a formal change control process to ensure that changes are not inadvertently introduced and that required system performance is not compromised. Post maintenance or modification testing must be conducted to confirm continued capability to fulfill system requirements.

d. CSE Support for Operations and Maintenance. The CSE must:

(1) ensure that system configuration is being managed effectively (see Section 3.c. of this Chapter);

(2) remain apprised of operational status and ongoing modification activities;

(3) assist operations review of key system parameters and evaluate system performance;

(4) initiate actions to correct problems;

(5) remain cognizant of system-specific maintenance and operations history and industry operating experience, as well as manufacturer and vendor

recommendations and any product warnings regarding their assigned systems;

(6) identify trends from operations and maintenance;

(7) provide assistance in determining operability, correcting out-of-specification conditions, and evaluating questionable data;

(8) provide or support analysis when the system is suspected of inoperability or degradation;

(9) review and concur with design changes, use-as-is, equivalency, and commercial grade dedication determinations; and

(10) review, and provide input into the development of, and concur on operating, maintenance, and test procedures related to their assigned systems.

e. CSE Qualification Requirements. Qualification requirements for CSEs must be consistent with those defined for Technical Support personnel in DOE O 426.2, Admin. Chg. 1, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities* (see associated CRD), as applicable. Qualification requirements must include knowledge of:

(1) related facility safety bases including safety system functions, safety system performance criteria, and any relationship to SACs;

(2) system functional classification and bases;

(3) codes and standards applicable to assigned systems;

(4) system design, procurement, replacement, and related quality assurance requirements;

(5) the existing condition of the systems;

(6) related facility operations; and

(7) vendor manuals, product warnings, and updates related to assigned systems, available (in print or online).

DESIGN CRITERIA FOR SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

This attachment provides requirements for the design and construction of safety structures, systems, and components (SSCs).

1. OBJECTIVE. To establish requirements for the design and construction of safety SSCs, both safety class and safety significant, by identifying an applicable set of industry codes and standards, as well as Department of Energy (DOE) design criteria, standards, and directives. Compliance with these requirements will ensure reliable performance of the safety function of safety SSCs under those conditions and events for which they are intended.

2. APPLICABILITY.

   a. This attachment applies to the design and construction of:

      (1) new hazard category 1, 2, and 3 nuclear facilities as defined by 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*; and

      (2) major modifications to hazard category 1, 2, and 3 nuclear facilities, as defined in 10 CFR Part 830, that substantially change the facility safety basis.

   b. This attachment does not impose requirements on existing facilities, except for major modifications to those facilities. The requirements of this attachment may be used to develop comparisons of existing facilities to the requirements for new facilities.

   c. This attachment does not apply to nuclear deactivation or decontamination and decommissioning activities at end-of-facility-life, if the safety analysis demonstrates that adequate protection is provided consistent with the requirements of 10 CFR Part 830 through alternate means and it is not cost-beneficial to apply the provisions of this attachment for the limited remaining life of the activity.

3. REQUIREMENTS. Safety SSCs must be designed, commensurate with the importance of the safety functions performed, to perform their safety functions when called upon, as determined by the safety analysis.

   a. General Design Criteria.

      (1) Conservative Design Margin. Safety SSCs must be designed with appropriate margins of safety, as defined in applicable DOE or industry codes and standards.

(2) System Reliability.

(a) The single failure criterion, requirements, and design analysis identified in Institute of Electrical and Electronics Engineers (IEEE) 379-2014, *IEEE Standard for Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems*, must be applied to safety class SSCs during the design process as the primary method of achieving reliability, unless another applicable standard is approved by DOE in accordance with the process for obtaining DOE review and approval of the applicability of codes and standards as described in DOE-Standard (STD)-1189-2016. ANSI/ANS 58.9-2002 (R2015), *Single Failure Criteria for LWR Safety-Related Fluid Systems*, may be used in defining the scope of active safety class mechanical SSCs.

(b) Safety significant SSCs must be designed to reliably perform all their safety functions. This can be achieved through a number of means, including use of redundant systems/components, increased testing frequency, high reliability components, and diagnostic coverage (e.g., on-line testing; monitoring of component and system performance; and monitoring of various failure modes). DOE-STD-1195-2011, *Design of Safety Significant Safety Instrumented Systems Used at DOE Nonreactor Nuclear Facilities*, provides an acceptable method for achieving high reliability of safety significant safety instrumented systems.

(2) Environmental Qualification.

(a) Safety class SSCs must be designed to perform all safety functions with no failure mechanism that could lead to common cause failures under postulated service conditions. The requirements of IEEE 323-2003 (R2008), *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations,* must be used to ensure environmental qualifications of safety class SSCs, unless another applicable standard is approved by DOE in accordance with the process for obtaining DOE review and approval of the applicability of codes and standards as described in DOE-STD-1189-2016.

(b) Safety significant SSCs located in a harsh environment must be evaluated to establish qualified life. This may be accomplished using manufacturers' recommendations or other appropriate methods.

(3) Safe Failure Modes. The facility design must provide reliable safe conditions and sufficient confinement of hazardous material during and

after all design basis accidents (DBAs). At both the facility- and SSC-level, the design must ensure that most probable modes of failure (e.g., failure to open versus failure to close) will increase the likelihood of a safe condition.

(4) Support System and Interface Design.

(a) Support SSCs must be designed as safety class or safety significant SSCs if their failures prevent safety SSCs or specific administrative controls (SACs) from performing their safety functions.

(a) Interfaces—such as pressure retention boundaries, electrical supply, instrumentation, cooling water, and other support systems—may exist between safety SSCs and non-safety SSCs. These interfaces must be evaluated to identify SSC failures that would prevent safety SSCs from performing their intended safety function. IEEE 384-2008, *IEEE Standard Criteria for Independence of Class IE Equipment and Circuits*, must be used for physical and electrical separation methods, including the use of separation distance, barriers, electrical isolation devices, or any combination thereof, unless another applicable standard is approved by DOE in accordance with the process for obtaining DOE review and approval of the applicability of codes and standards as described in DOE-STD-1189-2016. This application includes a design to ensure that both direct and indirect impacts of DBAs (e.g., fire, seismic) will not cause failure of safety functions.

(5) 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.

(6) Quality Assurance. A quality assurance program must be established that satisfies 10 CFR Part 830, Subpart A, "Quality Assurance Requirements," and DOE Order (O) 414.1D, Admin. Chg. 1, *Quality Assurance*, early in the project, such that safety SSCs and their associated support systems are designed, procured, fabricated, erected, and tested to standards and quality requirements commensurate with their importance to safety.

b. Specific Design Criteria and Use of National Codes and Standards. The selection and use of an appropriate set of applicable codes and standards establishes design criteria to provide assurance that the SSCs are designed to reliably perform their intended functions. The DOE technical standards and industry codes and standards identified below, which are widely used for nuclear facility design and construction, must be evaluated for applicability.

DOE technical standards and industry codes and standards are considered applicable when they provide relevant design requirements for the safety SSCs that are being designed (i.e., they provide design requirements that are needed to ensure that desired SSC functions are achieved, and these requirements are appropriate for the design materials, configuration, and service conditions). Further, the use of specific codes and standards may be directed by the DOE Head of Field Element. (Note: The stated applicability of industry codes and standards (e.g., for nuclear reactors) should not be used to narrowly interpret relevancy for SSC design.)

Before using these codes and standards, their application to specific DOE design(s) must be reviewed. Once a code or standard is identified as applicable, the applicable requirements (i.e., mandatory statements) must be applied in the design. The process for obtaining DOE review and approval of the applicability of codes and standards is described in DOE-STD-1189-2016.

The Safety Design Strategy developed in accordance with DOE-STD-1189-2016 may be used to specify provisions for relief (exemptions and equivalencies) from identified, applicable design and construction codes and standards. If the Safety Design Strategy is not used to specify relief provisions, the process for obtaining relief (i.e., equivalencies or exemptions) from applicable requirements in applicable DOE technical standards and industry codes and standards is described in Attachment 1 of DOE O 420.1C. (Note: Relief is not necessary for requirements within an applicable industry code or standard where the requirements are not relevant to the design or construction. Relief from Order 420.1C requirements, including requirements to follow invoked standards, would still be required to follow Attachment 1, Section 2.a, unless the requirements specifically relate to satisfying DOE technical standards and industry codes and standards that have been identified as applicable.)

The set of codes and standards identified below is not meant to be all-inclusive. It is expected that design of SSCs will require selection of additional codes and standards beyond those identified below. For example, unique design features, detailed design considerations, and release of advancements may drive selection of additional codes and standards. Facility designers must identify the complete set of codes and standards necessary to meet the general design criteria identified above (see also Attachment 4 of DOE O 420.1C for additional codes and standards).

(1) Structural. Table 1 provides relevant codes and standards. Attachment 2, Chapter IV of DOE O 420.1C provides additional natural phenomena hazards (NPH) design requirements.

Table 1: Codes for Safety Significant and Safety Class Structures

Structures	Safety Significant	Safety Class
Concrete	ACI-318; ACI-349	ACI-349
Steel	ANSI/AISC 360; AISC 325; ANSI/AISC N690	ANSI/AISC N690

Note: See DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, for further discussion on selection and use of codes for structural design of SSCs.

(2) Mechanical and Process Equipment. Table 2 provides relevant codes and standards.

Table 2: Codes for Safety Significant and Safety Class Process Equipment

Process Equipment	Safety Significant	Safety Class
Pressure vessels	ASME BPVC, Section VIII, Division 1 or 2	ASME BPVC, Section VIII, Division 1 or 2
Tanks (0-15 psig)	API-620; ASME BPVC Section VIII, Division 1 or 2	API-620; ASME BPVC, Section VIII, Division 1 or 2
Tanks (containing flammable liquids)	API-620; API-650; Applicable NFPA codes and standards	API-620; API-650; Applicable NFPA codes and standards
Tanks (atmospheric pressure)	API-650; AWWA D100	API-650; AWWA D100
Pumps	ASME B73.1, B73.2; ASME BPVC, Section VIII; AWWA D100; Hydraulic Institute Standards, as applicable	ASME B73.1, B73.2; ASME BPVC, Section VIII; AWWA D100; Hydraulic Institute Standards, as applicable
Piping	ASME B31.3	ASME B31.3
Valves	ASME B16.5; B31.3; ANSI N278.1	ASME B16.5; B31.3; ANSI N278.1
Heat Exchangers	ASHRAE Handbook; ASME BPVC, Section VIII, Division 1; TEMA B, C, or R	ASHRAE Handbook; ASME BPVC, Section VIII, Division 1; TEMA B, C, or R
Gloveboxes	ASTM C852; AGS-G006	ASTM C852; AGS-G006

(3) Ventilation. Table 3 provides relevant codes and standards.

Appendix A of DOE Guide (G) 420.1-1A, *Nonreactor Nuclear Safety Design Criteria for use with DOE O 420.1C, Facility Safety*, and DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*, provide guidance for confinement ventilation systems design and performance criteria. Alternate methods must be approved by DOE Heads of Field Element.

Table 3: Codes for Safety Significant and Safety Class Ventilation System Components

Ventilation	Safety Significant	Safety Class
Ducts	ASME AG-1	ASME AG-1
Fans	ASHRAE Handbook; ASME AG-1	ASHRAE Handbook; ASME AG-1
Filtration	ASME AG-1; DOE-STD-3020-2015	ASME AG-1; DOE-STD-3020-2015
Balance of system for confinement ventilation	ASME AG-1	ASME AG-1
Off-gas treatment	ASME AG-1	ASME AG-1

(4) Mechanical Handling Equipment. Table 4 provides relevant codes and standards.

Table 4: Codes for Safety Significant and Safety Class Handling Equipment

Handling Equipment	Safety Significant	Safety Class
Cranes	Applicable CMAA standards; ASME NOG-1; ASME NUM-1; ASME B30.2; DOE-STD-1090-2011	Applicable CMAA standards; ASME NOG-1; ASME NUM-1; ASME B30.2; DOE-STD-1090-2011
Other equipment	ASME B30 Series: DOE-STD-1090-2011	ASME B30 Series; DOE-STD-1090-2011

(5) Electrical. Tables 5 and 6 provide relevant codes and standards.

Note: ANSI/IEEE standards, below, define requirements for the manufacturing, installation, and testing of commercial reactor Safety-Class 1E electrical systems and components. While these requirements may not be directly applicable to nonreactor nuclear facilities, these standards contain useful and significant information that should be considered.

Table 5: Codes for Safety Significant and Safety Class Electrical Systems

Electrical	Safety Significant	Safety Class
Hardware	Applicable NFPA codes and standards; IES HB-10; IEEE C2, C37; IEEE-80, -141, -142, -242, -399, -446 493, -577	Applicable NFPA codes and standards; IES HB-10; IEEE C2, C37; IEEE-80, -141, -142, -242, -308, -338, -379 , -384, -399, -493, -577

Table 6: IEEE Standards used for Both Safety Significant and Safety Class Electrical Systems, as appropriate

Electrical	Safety Significant and Safety Class
Guidance standards for use as applicable for specific hardware	IEEE-323, -334, -336, -344, -352 -382, -383, -387, -420, -450, -484, -493, -535, -603, -627, -628, -649 , -650, -833, -946

(6) Instrumentation, Control, and Alarm Systems. The design of safety class instrumentation and control systems must incorporate sufficient independence, redundancy, diversity, and separation to ensure that all safety-related functions associated with such equipment can be performed. Safety significant components must be evaluated as to the need for redundancy on a case-by-case basis. DOE-STD-1195-2011 provides an acceptable method for achieving high reliability of safety significant safety instrumented systems.

Table 7 provides relevant codes and standards. The codes and standards for electrical systems (in Tables 5 and 6) may also be applicable to design of instrumentation and control systems and need to be evaluated in this context.

Table 7: Codes for Safety Significant and Safety Class Instrumentation, Control, and Alarm Components.

Instruments, Controls, and Alarms	Safety Significant	Safety Class
Hardware	Applicable NFPA codes and standards; ANSI/ANS-8.3, -58.8, -N13.1, -N323D; ANSI/ISA-Series including ISA 67.04.01 and ISA TR 84.00.06; IEEE-C2, -N42.18, -1023,	Applicable NFPA codes and standards; ANSI/ANS-8.3, 58.8, -N13.1, ANSI-N323D; ANSI/ISA-Series including ISA 67.04.01 and ISA TR 84.00.06; IEEE-C2, -N42.18, -603,

Instruments, Controls, and Alarms	Safety Significant	Safety Class
	-1050; -7-4.3.2; and DOE-STD-1195-2011	-1023, -1050, -7-4.3.2

(7) Fire Protection Systems. DOE-STD-1066-2016, *Fire Protection*, provides acceptable methods for the design of fire protection systems. Design requirements for safety class and safety significant fire barriers, water supplies, and wet pipe sprinkler systems are provided in Appendix A of DOE-STD-1066-2016. Fire protection system designs are also required to address the applicable design requirements for similar safety systems provided in this attachment.

c. Nuclear Reactor Safety Design Criteria. Nuclear reactors are an important class of DOE facilities that require special attention to design criteria and standards to ensure safe design and operations.

(1) The Code of Record for existing DOE nuclear reactors has been established by their designs. When a major modification is made to an existing reactor, the existing Code of Record is the starting point for the design of the major modification, and a design upgrade analysis is required in accordance with DOE-STD-1189-2016 to evaluate the application of nuclear safety design criteria and requirements. This design upgrade analysis may identify updated nuclear reactor safety design criteria and updated codes and standards to be applied to the major modification.

(2) For any new DOE nuclear reactor, a set of reactor-specific safety design criteria and a set of reactor design codes and standards must be established in accordance with the Safety Design Strategy required by DOE-STD-1189-2016. Existing industry codes and standards should be used to the extent possible.

REFERENCES AND ACRONYMS

1. REFERENCES. The following reference documents and information sources are cited to assist in implementing this Order. This attachment does not provide a complete listing of industry codes and standards that may be needed.

   a. Public Law (Pub. L.).

      (1) Pub. L. 83-703, *Atomic Energy Act of 1954*, as amended.

      (2) Pub. L. 94-580, *Resource Conservation and Recovery Act of 1976* (RCRA), as amended.

      (3) Pub. L. 106-65, *National Defense Authorization Act for Fiscal Year 2000*, as amended.

   b. Executive Orders (E.O.) and Federal Policies.

      (1) E.O. 12344, Naval Nuclear Propulsion Program, 02-01-1982.

      (2) Federal Wildland Fire Management Policy, National Interagency Fire Center, 1995 (R 2001).

      (3) Secretarial Delegation Order Number 00-033.00C, 08-12-2016.

   c. Code of Federal Regulations (CFR).

      (1) 10 CFR Part 830, Nuclear Safety Management.

      (2) 10 CFR Part 835, Occupational Radiation Protection.

      (3) 10 CFR Part 851, Worker Safety and Health Program.

      (4) 29 CFR Part 1910, Occupational Safety and Health Standards.

      (5) 29 CFR Part 1926, Safety and Health Regulations for Construction.

      (6) 48 CFR Part 970, Section 970.5223-1, “Integration of Environment, Safety, and Health into Work Planning and Execution.”

   d. DOE Directives.

      (1) DOE P 420.1, *Department of Energy Nuclear Safety Policy*, 02-08-11.

      (2) DOE O 151.1D, *Comprehensive Emergency Management System*, 8-11-16.

(3) DOE O 226.1B, *Implementation of Department of Energy Oversight Policy*, 04-25-11.

(4) DOE O 227.1A, *Independent Oversight Program*, 12-21-15.

(5) DOE O 251.1D, *Departmental Directives Program*, 01-17-17.

(6) DOE O 410.1, *Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements*, 08-28-07.

(7) DOE O 413.3B Chg. 5, *Program and Project Management for the Acquisition of Capital Assets*, 04-12-18.

(8) DOE O 414.1D, Admin. Chg. 1, *Quality Assurance*, 05-08-13.

(9) DOE O 420.2C, *Safety of Accelerator Facilities*, 07-21-11.

(10) DOE O 426.2 Admin. Chg. 1, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*, 07-29-13.

(11) DOE O 433.1B Chg. 1, *Maintenance Management Program for DOE Nuclear Facilities*, 03-12-13.

(12) DOE O 435.1 Chg. 1, *Radioactive Waste Management*, 01-09-07.

(13) DOE O 450.2, *Integrated Safety Management*, 04-25-11.

(14) DOE O 452.1E, *Nuclear Explosive and Weapon Surety Program*, 01-26-15.

(15) DOE O 452.2E, *Nuclear Explosive Sa*fety, 01-26-15.

(16) DOE M 435.1-1 Chg. 2, *Radioactive Waste Management Manual*, 06-08-11.

(17) DOE G 413.3-21 Chg. 1, *Cost Estimating Guide*, 10-22-15.

(18) DOE G 414.1-2B Chg. 2, Quality Assurance Program Guide, 05-08-13.

(19) DOE G 414.1-4, *Safety Software Guide for use with 10 C.F.R 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance*, 11-03-10.

(20) DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Criteria for Use with DOE O 420.1C, Facility Safety*, 12-04-12.

e. DOE Technical Standards (STDs).

(1) DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*.

(2) DOE-STD-1027-1992, Chg. 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, September 1997.

(3) DOE-STD-1066-2016, *Fire Protection*.

(4) DOE-STD-1073-2016, *Configuration Management*.

(5) DOE-STD-1090-2011, *Hoisting and Rigging*. (Formerly Hoisting and Rigging Manual).

(6) DOE-STD-1098-2008, *Radiological Control*.

(7) DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*.

(8) DOE-STD-1128-2013, *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities*.

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

(10) DOE-STD-1186-2016, *Specific Administrative Controls.*

(11) DOE-STD-1189-2016, *Integration of Safety into the Design Process*.

(12) DOE-STD-1195-2011, *Design of Safety Significant Safety Instrumented Systems Used at DOE Nonreactor Nuclear Facilities*.

(13) DOE-STD-1212-2012, *Explosives Safety*.

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

(15) DOE-STD-3007-2017, *Preparing Criticality Safety Evaluations at DOE Nonreactor Nuclear Facilities*.

(16) DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chg. Notice 3, March 2006.

(17) DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*.

(18) DOE-STD-3020-2015, *Specifications for HEPA Filters Used by DOE Contractors.*

(19) DOE-STD-3024-2011, *Content of System Design Descriptions.*

f. DOE Handbooks (HDBKs).

(1) DOE-HDBK-1132-1999, *Design Considerations*.

(2) DOE-HDBK-1163-2003, *Integration of Multiple Hazard Analysis Requirements and Activities.*

(3) DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook.*

g. Department of Defense.

MIL-STD-1472F, *Department of Defense Design Criteria Standard: Human Engineering*, August 1999.

h. American Concrete Institute (ACI).

ACI 349-06, Code *Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-06) and Commentary*, 2006.

e. American Conference of Governmental Industrial Hygienists (ACGIH).

ACGIH 2096, *Industrial Ventilation: A Manual of Recommended Practices for Design*, January 2010.

f. American Glovebox Society (AGS).

AGS-G006-2005, *Standard of Practice for the Design and Fabrication of Nuclear Application Gloveboxes*, 2005.

i. American National Standards Institute (ANSI).

(1) ANSI N13.1-2011, *Guide to Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*, 2011.

(2) ANSI N43.2-2001 (R2010), *Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment*, 2001.

(3) ANSI N278.1-1975 (R1992), *Self-Operated and Power-Operated Safety-Related Valves Functional Specification Standard*, 1975.

(4) ANSI N323D-2002, *American National Standard for Installed Radiation Protection Instrumentation*, 2002.

(5) ANSI/AIHA Z9.2-2012, *Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems*, 2012.

(6) ANSI Z358.1-2009, *American National Standard for Emergency Eyewash and Shower Equipment,* 2009.

j. American National Standards Institute/American Institute of Steel Construction (AISC).

(1) AISC 325:2011, *Steel Construction Manual*, 2011.

(2) ANSI/AISC 360:10, *Specification for Structural Steel Buildings*, 2010.

(3) ANSI/AISC N690-12, *Specification for Safety-Related Steel Structures for Nuclear Facilities*, 2012.

k. American National Standards Institute/American Nuclear Society (ANS).

(1) ANSI/ANS-1-2000 (R2007) (R2012), *Conduct of Critical Experiments*, 2000.

(2) ANSI/ANS-6.4.2-2006, *Specification for Radiation Shielding Materials*, 2006.

(3) ANSI/ANS-8 Series Standards.

(4) ANSI/ANS-8.1-2014, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, 2014.

(5) ANSI/ANS-8.3-1997 (R2003) (R2012), *Criticality Accident Alarm System*, 1997.

(6) ANSI/ANS-8.15-2014, *Nuclear Criticality Safety Control of Selected Actinide Nuclides*, 2014.

(7) ANSI/ANS-14.1-2004 (R2009) (R2014), *Operation of Fast Pulse Reactors*, 2004.

(8) ANSI/ANS-58.8-1994 (R2001) (R2008), *Time Response Design Criteria for Safety-Related Operator Actions,* 1994.

(9) ANSI/ANS-58.9-2002 (R2015), *Single Failure Criteria for LWR Safety-Related Fluid Systems*, 1981.

l. American National Standards Institute/International Society of Automation (ISA).

(1) ANSI/ISA 7.0.01-1996, *Quality Standard for Instrument Air*, 1996.

(2) ANSI/ISA 18.1-1979 (R2004), *Annunciator Sequences and Specifications*, 1979.

(3) ANSI/ISA 67.01.01-2002 (R2007), *Transducer and Transmitter Installation for Nuclear Safety Applications*, 2002.

(4) ANSI/ISA S67.02.01-1999, *Nuclear-Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants*, 1999.

(5) ANSI/ISA 67.04.01-2006 (R2011), *Setpoints for Nuclear Safety-Related Instrumentation*, 2006.

m. American Petroleum Institute (API).

(1) API-620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, 2013.

(2) API-650, *Welded Tanks for Oil Storage*, 2013.

n. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

(1) ASHRAE Handbook, *Fundamentals* (Inch-Pound Edition), 2013.

(2) ASHRAE Standard 62.1-2010, *Ventilation for Acceptable Indoor Air Quality*, 2010.

o. American Society of Mechanical Engineers (ASME).

(1) ASME AG-1-2015, *Code on Nuclear Air and Gas Treatment*, 2015.

(2) ASME BPVC, *Boiler and Pressure Vessel Code*, 2015.

(3) ASME B16.5-2013, *Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard*, 2013.

(4) ASME B30.2-2011, *Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder*, Top Running Trolley Hoist), 2011.

(5) ASME B31.3-2014, *Process Piping*, 2014.

(6) ASME B73.1-2012, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*, 2012.

(7) ASME B73.2-2003 (R2009), *Specifications for Vertical In-Line Centrifugal Pumps for Chemical Process*, 2003.

(8) ASME NOG-1-2010, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)*, 2010.

(9) ASME NUM-1-2009, *Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)*, 2009.

(10) ASME NQA-1-2012, *Quality Assurance Requirements for Nuclear Facility Applications*, 2013.

p. ASTM International.

(1) ASTM C852-09, *Standard Guide for Design Criteria for Plutonium Gloveboxes*, 2009.

(2) ASTM C1455-14e1, *Standard Test Method for Nondestructive Assay of Special Nuclear Material Holdup Using Gamma-Ray Spectroscopic Methods*, 2014.

g. American Water Works Association (AWWA).

AWWA D100-11, *Welded Carbon Steel Tanks for Water Storage*, 2011.

h. Crane Manufacturers Association of America (CMAA).

CMAA Standards, as applicable.

i. Defense Nuclear Facilities Safety Board (DNFSB).

DNFSB Recommendation 2004-2, *Active Confinement Systems.*

j. Hydraulic Institute Standards.

Hydraulic Institute Standards, as applicable.

k. Illuminating Engineering Society (IES).

IES HB-10-11, *IES Lighting Handbook*, 2011.

l. Institute of Electrical and Electronics Engineers (IEEE)/International Electrotechnical Commission (IEC).

(3) IEEE C2-2017, *National Electrical Safety Co*de, 2017.

(4) IEEE C37 *Standards Collection, Power Switchgears, Substations, and Relays, Standards on switchgear as applicable*, 2010.

(5) IEEE N42.18-2004, *American National Standard Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents*, 2004.

(6) IEEE N323D-2002, *American National Standard to Installed Radiation Protection Instrumentation*, 2003.

(7) IEEE 7-4.3.2-2016, *IEEE Standard Criteria for Programmable Digital Devices in Safety Systems of Nuclear Power Generating Stations*, 2016.

(8) IEEE 80-2013, IE*EE Guide for Safety in AC Substation Grounding*, 2013.

(9) IEEE 141-1993 (R1999), *IEEE Recommended Practice for Electric Power Distribution for Industrial Plants*, 1993.

(10) IEEE 142-2007, *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems*, 2007.

(11) IEEE 242-2001, *IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)*, 2001.

(12) IEEE 308-2012, *IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations*, 2012.

(13) IEEE 323-2003 (R2008), *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations*, 2003.

(14) IEEE 334-2006 (R2012), *IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations*, 2006.

(15) IEEE 336-2010, *IEEE Recommended Practice for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities*, 2010.

(16) IEEE 338-2012, *IEEE Standard for Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety*, 2012.

(17) IEEE 344-2013, *IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations*, 2013.

(18) IEEE 352-1987, *IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Safety Systems*, 1987.

(19) IEEE 379-2014, *IEEE Standard for Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems*, 2014.

(20) IEEE 382-2006, *IEEE Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations*, 2006.

(21) IEEE 383-2015, *IEEE Standard for Qualifying Electric Cables and Splices for Nuclear Facilities*, 2015.

(22) IEEE 384-2008, *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits*, 2008.

(23) IEEE 387-1995 (R2007), *IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generation Stations*, 1995.

(24) IEEE 399-1997, *IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book)*, 1997.

(25) IEEE 420-2013, *IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations*, 2013.

(26) IEEE 446-1995 (R2000), IE*EE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications*, 1995.

(27) IEEE 450-2010, I*EEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*, 2010.

(28) IEEE 484-2002, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*, 2002.

(29) IEEE 493-2007, *IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems*, 2007.

(30) IEEE 535-2013, *IEEE Standard for Qualification of Class 1E Vented Lead Acid Storage Batteries for Nuclear Power Generating Stations*, 2013.

(31) IEEE 577-2012, *IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations*, 2012.

(32) IEEE 603-2009, *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations*, 2009.

(33) IEEE 627-2010, *IEEE Standard for Qualification of Equipment Used in Nuclear Facilities*, 2010.

(34) IEEE 628-2011, *IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations*, 2011.

(35) IEEE 649-2006 (R2011), *IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations*, 2006.

(36) IEEE 650-2006, *IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations*, 2006.

(37) IEEE 833-2005 (R2011), *IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards*, 2005.

(38) IEEE 946-2004, *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Systems*, 2004.

(39) IEEE 1023-2004 (R2010), *IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and other Nuclear Facilities*, 2004.

(40) IEEE 1050-2004, I*EEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations*, 2004.

m. International Code Council (ICC).

ICC, *International Building Code*, 2015.

n. International Society of Automation (ISA).

ISA-TR84.00.06, *Safety Fieldbus Design Considerations for Process Industry Sector Applications*, 2009.

o. National Council on Radiation Protection and Measurements (NCRP).

NCRP Report 49, "Structural Shielding Design and Evaluation for Medical Use of X Rays and Gamma Rays of Energies Up to 10 MeV," 1976.

q. National Fire Protection Association (NFPA).

(1) NFPA 30, *Flammable and Combustible Liquids Code*, 2015.

(2) NFPA 70, *National Electric Code*, 2017.

(3) NFPA 72, *National Fire Alarm and Signaling Code*, 2016.

(4) NFPA 101, *Life Safety Code*, 2015.

(5) NFPA 110, *Standard for Emergency and Standby Power Systems*, 2016.

(6) NFPA 780, *Standard for the Installation of Lightning Protection System*s, 2017.

(7) NFPA 1143, *Standard for Wildland Fire Management*, 2014.

r. Nuclear Regulatory Commission (NRC).

NUREG-0700, *Human-System Interface Design Review Guidelines*, 2002.

s. Tubular Exchanger Manufacturers Association (TEMA).

TEMA, 9th Edition *TEMA Standards*: Standards on Heat Exchangers Classes B, C, and R. Appendix F, Concluding Material. New York, 2007.

ACRONYMS.

AHJ	Authority Having Jurisdiction
ANS	American Nuclear Society
ANSI	American National Standards Institute
BNA	Baseline Needs Assessment
CD	Critical Decision
CFR	Code of Federal Regulations
COR	Code of Record
CRD	Contractor Requirements Document
CSE	Cognizant System Engineer
CSP	Criticality Safety Program
DBA	Design Basis Accident
DOE	Department of Energy
DSA	Documented Safety Analysis
FHA	Fire Hazards Analysis
FPE	Fire Protection Engineer
G	Guide
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
M	Manual
MPFL	Maximum Possible Fire Loss
NFPA	National Fire Protection Association
NPH	Natural Phenomena Hazards
O	Order
P	Policy
SAC	Specific Administrative Controls
SSC	Structures, Systems, and Components
STD	Standard