E. The edition(s) of the codes and standards used in the design shall be referenced in the DBD and construction drawings *(as noted in 1.5.C and 1.5.H*). The use of the documents listed under References below (e.g., various codes, standards, reports, papers, etc.) might be necessary in order to comply with this Chapter.

## 2.0 ACRONYMS AND NOTATIONS[18]

The following is a list of acronyms, notation, symbols, and shortened titles used in this Chapter. Load-related symbols and factors are defined in Sections II and III.

AA – Aluminum Association

AASHTO – American Association of State Highway and Transportation Officials

ACI – American Concrete Institute

ADM – Aluminum Design Manual

AISC – American Institute of Steel Construction

AISI – American Iron and Steel Institute

ANSI – American National Standards Institute

API – American Petroleum Institute

ASCE – American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM – ASTM International

ASD – Allowable Stress Design

ATC – Applied Technology Council

ASME – American Society of Mechanical Engineers

AWS – American Welding Society

BLEVE – Boiling Liquid Expanding Vapor Explosion

BNL – Brookhaven National Laboratory

CE – Carbon Equivalent

CIP – Cast in place

CFR – Code of Federal Regulations

DBD – Design Basis Document

DBE – Design Basis Earthquake

DOD – Department of Defense

DOD-TM - Department of Defense Technical Manual

DOE G – Department of Energy Guideline

DOE M – Department of Energy Manual

DOE O – Department of Energy Order

DOE-STD – Department of Energy Standard

ESM – Engineering Standards Manual

$F_\mu$ – Inelastic Energy Absorption Factor

FDD – Facility Design Description

FEMA – Federal Emergency Management Agency

FIMS – Facility Information Management System

HC – Hazard Category

HVAC – Heating Ventilation and Air Conditioning

I, $I_p$ – Importance Factor

IBC – International Building Code

ICC – International Code Council

ICC ES – International Code Council Evaluation Service

IEBC – International Existing Building Code

[18] The acronyms and notations listed herein are not intended to be only/all of those used in this chapter, nor are they intended to be all of those that might be required by the documents referenced in this chapter. Rather the listing is merely intended to include some of the more commonly used acronyms and notations in the chapter and in the documents referenced in it.

IEEE – Institute of Electrical and Electronics Engineers

IMP – Implementation procedure

ISD – Implementation Support Documents

LANL – Los Alamos National Laboratory

LANS – Los Alamos National Security, LLC

LLNL – Lawrence Livermore National Laboratory

LRFD – Load & Resistance Factor Design

ML – Management Level

NASPEC – North American Specification

NDC – NPH Design Category

NEMA – National Electrical Manufacturers Association

NFPA – National Fire Protection Association

NNSA – National Nuclear Security Administration

NPH – Natural Phenomena Hazard

NRC/NUREG – Nuclear Regulatory Commission

OEITS – other equipment important to safety

PI – Post-installed

POC – Point of Contact

QA – Quality Assurance

R, $R_p$ – Response Modification Coefficient

RC – Risk Category

RFP – Request for Proposal

$S_{D1}$ – Response Spectral Acceleration at 1 Second Period

$S_{DS}$ – Peak Response Spectral Acceleration (0.2 Second Period)

SD – Strength Design

SDC – Seismic Design Category

SDD – System Design Description

SDQP - Structural Design Quality Plan

SF – Scale Factor

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

SPRP – Structural Peer Review Plan

SSCs – Structures, Systems, and Components

TEMA – Tubular Exchanger Manufacturers Association

UFC – Unified Facilities Criteria

UHRS – Uniform Hazard Response Spectrum

$\phi$ – Capacity Reduction Factor

## 3.0 DEFINITIONS

**Anchor** – A steel element either cast into concrete or masonry, or post installed into a hardened concrete or masonry member. Including headed bolts, hooked bolts (J- or L- bolt), headed studs, expansion anchors, undercut anchors, etc. Anchors in the context of the ESM also include steel to steel connection elements and welds. Anchors are used to transmit applied loads.

**Anchorage** – A device or a collection of devices that provide structural support or restraint for systems and components to prevent falling, sliding, overturning, and excessive displacement.

**Attachment** – The structural assembly, external to the surface of the concrete that transmits loads to or receives loads from the anchor.

**Corrosive** – A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. A chemical shall be considered corrosive if, when tested on the intact skin of albino rabbits by the method described in DOT 49 CFR, Part 173.137, such chemical destroys or changes irreversibly the structure of the tissue at the point of contact following an exposure period of 4 hours. This term does not refer to action on inanimate surfaces. [IBC 2015]

**Exceedance frequency** – The annual probability of exceeding a given ground motion. For example, at LANL, the 2007 UPSHA[19] has estimated that the mean exceedance frequency associated with a peak ground acceleration of 0.47g is $4 \times 10^{-4}$ (i.e., 1/2500) or an average return period of 2,500 years.

**Existing facility** – Refer to IBC definition and any ESM Chapter 16 amendment to same.

**Explosives facility** – A structure or defined area used for explosives storage or operations. Excluded are explosives presenting only localized, minimal hazards as determined by the Authority Having Jurisdiction. Examples of excluded items may include user quantities of small arms ammunition, commercial distress signals, or cartridges for cartridge actuated tools, etc. [DOE G 420.1-1A]

**Facility** – One or more building(s) or structure(s), including systems and components, dedicated to a common function (includes operating, non-operating, and facilities slated for decontamination and decommissioning).

**Inelastic energy absorption factor ($F_\mu$)** – A reduction factor used to reduce demand to account for inelastic behavior. The Inelastic Energy Absorption Factor is a function of the Limit State and the structural system or equipment configuration. See ASCE 43 for more detail.

**Graded approach** – A process by which the level of analysis, documentation, and actions necessary to comply with requirements are commensurate with: the relative importance to safety, safeguards, and security; the magnitude of any hazard involved; the life cycle stage of a facility; the programmatic mission of a facility; the particular characteristics of a facility; and any other relevant factor.

**Hazard** – A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel (workers or the public), damage to an operation, or damage to the environment (without regard for the likelihood or credibility of accident scenarios or consequence mitigation).

**Hazard categorization** – Evaluation of the consequences of unmitigated releases to classify facilities or operations into the following hazard categories:

- *Hazard Category 1: Has the potential for significant off-site consequences.*
- *Hazard Category 2: Has the potential for significant on-site consequences.*
- *Hazard Category 3: Has the potential for only significant localized consequences.*

DOE-STD-1027-92 provides guidance and radiological threshold values for determining the hazard category of a facility. DOE-STD-1027-92, Chg 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, interprets Hazard Category 1 facilities as Category A reactors and other facilities designated as such by the Program Secretarial Officer. [DOE G 420.1-1A]

**Hazardous material** – Any solid, liquid, or gaseous material that is radioactive, toxic, explosive, flammable, corrosive, or otherwise physically or biologically threatening to health. [DOE G 420.1-1A]

**Health hazard** – A classification of a chemical for which there is statistically significant evidence that acute or chronic health effects are capable of occurring in exposed persons. The term "health hazard" includes chemicals that are toxic or highly toxic, and corrosive. [2015 IBC]

[19] Refer to the URS Corp. document contained in Miscellaneous References herein.

**High confidence of low probability of failure (HCLPF)** – Usually a 90% confidence of a less than 10% probability of failure which results in about a 1% to 2% probability of failure

**Highly toxic** – A chemical which produces a lethal dose or lethal concentration that falls within any of the following categories:

1. Has a median lethal dose ($LD_{50}$) of $\leq$ 50 mg per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 g each.
2. Has an $LD_{50}$ of $\leq$ 200 mg per kilogram of body weight when administered by continuous contact for 24 hr (or less if death occurs within 24 hr) with the bare skin of albino rabbits weighing between 2 and 3 kg each.
3. Has an $LD_{50}$ in air of $\leq$ 200 parts per million by volume of gas or vapor, or $\leq$ 2 mg per liter of mist, fume, or dust, when administered by continuous inhalation for 1 hr (or less if death occurs within 1 hr) to albino rats weighing between 200 and 300 g each.

Mixtures of these chemicals with ordinary materials, such as water, might not warrant classification as highly toxic. While this system is basically simple in application, any hazard evaluation that is required for the precise categorization of this type of chemical shall be performed by experienced, technically competent persons. [adaptation of 2015 IBC]

**Limit state (LS)** – The limiting acceptable condition of the SSC. The limit state may be defined in terms of a maximum acceptable displacement, strain, ductility, or stress. The four LSs are as follows:

**A = Short of collapse, but structurally stable**

**B = Moderate permanent deformation**

**C = Limited permanent deformation**

**D = Essentially elastic**

**Major modification** – A modification/ change to a DOE nuclear facility that substantially changes the existing safety basis [adaptation of DOE-STD-1189-2008]. Determination is made through a checklist (see SBP114-1, *Safety Basis Development for Projects, Att 2).*

**Mean annual hazard** – The expected (or average) exceedance frequency associated with a given hazard. Future seismic loads are highly variable. For a given site, there is typically, a "mean annual seismic hazard" curve that expresses the average (or expected) value of a ground motion parameter, such as peak ground acceleration, as a function of the probability of exceedance of that variable.

**Natural phenomena hazard (NPH)** – An act of nature (e.g., earthquake, wind, tornado, flood, precipitation, volcanic eruption, or lightning strike) that poses a threat or danger to workers, the public, or to the environment by potential damage to structures, systems, and components.

**New facility** – Refer to IBC definition and any ESM Chapter 16 amendment to same.

**Nonreactor nuclear facility** – Those facilities, activities or operations that involve, or will involve, radioactive and/or fissionable materials in such form and quantity that a nuclear or a nuclear explosive hazard potentially exists to workers, the public, or the environment, but does not include accelerators and their operations and does not include activities involving only incidental use and generation of radioactive materials or radiation such as check and calibration sources, use of radioactive sources in research and experimental and analytical laboratory activities, electron microscopes, and x-ray machines. [DOE G 420.1-1A]

**Other equipment important to safety** – Refer to ESM Chapter 1 Section Z10 definition.

**Peak spectral acceleration** – The maximum acceleration response that a prescribed forcing function can produce in a single degree of freedom oscillator (independent of the natural frequency of the oscillator).

**Peer review** – A formal review process in which an external party (independent from the project) will review the methodology, results, and process by which a design is developed.

**Physical hazard** – A chemical for which there is evidence that it is a combustible liquid, cryogenic fluid, explosive, flammable (solid, liquid or gas), organic peroxide (solid or liquid), oxidizer (solid or liquid), oxidizing gas, pyrophoric (solid, liquid or gas), unstable (reactive) material (solid, liquid or gas), or water-reactive material (solid or liquid). [2015 IBC]

**Positive attachment/connection** – Anchors, bolts, welds, screws and other such fasteners, etc.; not relying on gravity or friction. [adapted from various; e.g., ASCE 7, IBC, SDI, etc.]

**Post-installed anchor** – An anchor installed in hardened concrete. Expansion, adhesive, and undercut anchors are examples of post-installed anchors.

**Response modification coefficient (R)** – A factor used to reduce demand (that would be generated by a commercial structure behaving elastically due to the design-basis earthquake) to target the development of the first significant yield. It accounts for the displacement ductility demand required by the system and the inherent overstrength of the seismic force-resisting system (SFRS). R is a function of the structural system configuration (i.e., the SFRS selected for use dictates the value of R). [adaptation of ASCE 7-10 Expanded Commentary on Ch. 12]

**Safety basis** – The documented safety analysis and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment. [DOE G 420.1-1A]

**Safety class** – A category for facilities or SSCs identified by a safety analysis whose importance to safety is to prevent or mitigate potential adverse consequences to the general public or the environment.

**Safety significant** – A category for facilities or SSCs identified by a safety analysis whose importance to safety is a preventative or mitigative function that is a major contributor to defense-in-depth and /or to prevent or mitigate potential adverse consequences to the facility workers or occupants.

**Seismic hazard curves (HC)** – Description of the ground motion parameter of interest as a function of annual frequency of exceedance. Peak ground acceleration and spectral accelerations at 0.2 sec and 1 second natural period plotted as a function of annual frequency of exceedance are common. The seismic hazard curves are determined from a probabilistic hazard assessment following the guidance in ANSI/ANS 2.27 and 2.29.

**Significant chemical or toxicological hazard** – A dose applied to /received by a facility worker, collocated worker, or the public that warrants protection (in the form of SSCs) against the hazard. The NPH categorization of the SSCs (e.g., RC-II, NDC-2, etc.) is based on the dose and the unmitigated consequences of SSC failure. The methodology for the categorization should be consistent with DOE-STD-1189 (i.e., Appendix B for collocated workers and the public, and Appendix C for facility workers) and direction from the responsible program office. [adapted from DOE-STD-1189 Appendices, and DOE-STD-1020]

**Spectral acceleration** – The maximum acceleration response of a single-degree or freedom oscillator of a known frequency, f and viscous damping, β, subjected to a prescribed forcing function or earthquake ground motion time history.

**Structural element** – Portion of a structure involved in a load path, such as a beam, column, shear wall, diaphragm, brace, anchor or support. [adapted from various places in ASCE 7]

**Structures, systems, and components (SSCs) –** A structure is an element, or a collection of elements, to provide support or enclosure, such as a building, free-standing tanks, basins, dikes, or stacks. A system is a collection of components assembled to perform a function, such as piping, cable trays, conduits, or HVAC. A component is an item of mechanical or electrical equipment, such as a pump, valve, or relay, or an element of a larger array, such as a length of pipe, elbow, or reducer.

**Toxic** – A chemical falling within any of the following categories [adaptation of 2015 IBC]:

1. Has a median lethal dose ($LD_{50}$) of > 50 mg per kg, but ≤ 500 mg/kg of body weight when administered orally to albino rats weighing between 200 and 300 g each.
2. Has an $LD_{50}$ of > 200 mg per kg, but ≤ 1,000 mg/kg of body weight when administered by continuous contact for 24 hr (or less if death occurs within 24 hr) with the bare skin of albino rabbits weighing between 2 and 3 kg each.
3. Has an $LD_{50}$ in air of > 200 parts per million, but ≤ 2,000 ppm by volume of gas or vapor, or > 2 mg per liter but ≤ 20 mg per liter of mist, fume, or dust, when administered by continuous inhalation for 1 hr (or less if death occurs within 1 hr) to albino rats weighing between 200 and 300 g each.

## 4.0 REFERENCES[20]

These documents are invoked by reference to the extent applicable. Dates shown are the latest at time of issuance of Section I; however, always use latest edition (except for those referenced by building code of record used).

**ACI (American Concrete Institute)**

- ACI 318, "Building Code Requirements for Structural Concrete," Code and Commentary, 2014.
- ACI 349, "Code Requirements for Nuclear Safety Related Concrete Structures," Code and Commentary, 2013
- ACI 349.1R, "Reinforced Concrete Design for Thermal Effects on Nuclear Power Plan Structures," 2007
- TMS 402 and 602/ACI 530 and 530.1/ASCE 5 and 6, "Building Code Requirements for Masonry Structures," and "Specification for Masonry Structures," respectively, 2013.

**AISC (American Institute of Steel Construction)**

- AISC 341 – Seismic Provisions for Structural Steel Buildings, including Supplement 1, 2010.
- AISC 360 – Specification for Structural Steel Buildings, 2010.

[20] The documents listed are those that are explicitly referenced in the chapter as well as some/many of those that are implicitly referenced (e.g., by way of their being referenced by IBC, etc.).

**AISI (American Iron Steel Institute)**

- AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members," 2012.
- AISI S110/S1, "Standard for Seismic Design of Cold-Formed Steel Structural Systems—Special Moment Frames," 2007 with Supplement 1, dated 2009 (R2012).
- AISI S200, "North American Standard for Cold-Formed Steel Framing – General Provision," 2012.
- AISI S210,"North American Standard for Cold-Formed Steel Framing - Floor and Roof System Design," (R2012)
- AISI S211/S1, "North American Standard for Cold-Formed Steel Framing - Wall Stud Design," 2007 including Supplement 1, dated 2012 (R2012).
- AISI S212, "North American Standard for Cold-Formed Steel Framing - Header Design," 2007 (R2012).
- AISI S213/S1, "North American Standard for Cold-Formed Steel Framing – Lateral Design," 2007, with Supplement 1, dated 2009 (R2012).
- AISI S214, "North American Standard for Cold-Formed Steel Framing - Truss Design," 2012.

**ANSI/AISC (American National Standards Institute/ American Institute of Steel Construction)**

- ANSI/AISC N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities, 2012.

**ANSI/ANS (American National Standards Institute/American Nuclear Society)**

- ANSI/ANS 2.26 "Categorization of Nuclear Facility Structures, Systems and Components for Seismic Design," 2004 (R2010).

**ASCE (American Society of Civil Engineers)**

- ASCE 4, "Seismic Analysis of Safety Related Nuclear Structures and Commentary," 1998.
- ASCE 7, "Minimum Design Loads for Buildings and Other Structures with Supplement No. 1," 2010.
- ASCE 8, "Specification for the Design of Cold-Formed Stainless Steel Structural Members," 2014.
- ASCE 19, "Standard Guidelines for the Structural Applications of Steel Cables for Buildings," 2009.
- ASCE 41, "Seismic Evaluation and Retrofit of Existing Buildings," 2013.
- ASCE 43, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," 2005.
- ASCE 59, "Blast Protection of Buildings," 2011.
- ASCE, "Design of Blast Resistant Buildings in Petrochemical Facilities," Task Committee on Blast Resistant Design, 1997.

- ASCE, "Structural Analysis and Design of Nuclear Plant Facilities, Manuals and Reports on Engineering Practice No. 58, 1980.
- ASCE, "Structural Design for Physical Security, State of the Practice," 1999.American Society of Civil Engineers.

**ASME (American Society of Mechanical Engineers)**

- NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications," March 14, 2008 with 2009 addenda.
- QME-1, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," 2007.

**ASTM International (formerly American Society of Testing Materials)**

- ASTM G 57, "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method," 2006.

**DOD (Department of Defense)**

- UFC 3-340-01, "Design and Analysis of Hardened Structures for Conventional Weapons Effects," Unified Facilities Criteria (UFC), 2002.
- UFC 4-010-01, "DoD Minimum Antiterrorism Standards for Buildings," Unified Facilities Criteria (UFC), October 8, 2003.
- UFC 4-010-02, "DoD Minimum Antiterrorism Standoff Distances for Buildings, Unified Facilities Criteria (UFC), January 2007.
- UFC 3-340-02, "Structures to Resist the Effects of Accidental Explosions, Unified Facilities Criteria (UFC), December 2008.

**DOE (Department of Energy) Regs, Orders, and Standards**

- 10 CFR Part 830, "Nuclear Safety Management," 2006.
- DOE O 414.1D, "Quality Assurance," 2011, Admin Chg. 1 (2013).
- DOE O 420.1C, "Facility Safety," Change 1 (2015).
- DOE G 420.1-1A, "Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety," December 2012.
- DOE M 440.1-1A, "Explosive Safety Manual," 2006.
- DOE-STD-1020, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities," December 2012.
- DOE-HDBK-TBD, "Natural Phenomena Hazards Analysis and Design Handbook for DOE Facilities," October 2014 draft.
- DOE-STD-1189, "Integration of Safety into the Design Process," March, 2008.
- DOE/EH-0545, "Seismic Evaluation Procedure for Equipment in the US DOE Facilities," March 1997.

**EPA (Environmental Protection Agency)**

- 40 CFR Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," 2002.

**ICC (International Code Council)**

- IBC, "2015 International Building Code," Copyright 2014, First Printing May 2014.
- IEBC, "2015 International Existing Building Code," Copyright 2014, First Printing May 2014.

**ICC-ES (Evaluation Service) AC (Acceptance Criteria)** (reference only; bases for ES Reports)

- AC01, "Expansion Anchors in Masonry Elements," August 2013
- AC58, "Adhesive Anchors in Masonry Elements," August 2013.
- AC106, "Predrilled Fasteners (Screw Anchors) in Masonry," May 2012

**NIST (National Institute of Standards and Technology)**

- NIST GCR 11-917-12, "Standards of Seismic Safety for Existing Federally Owned and Leased Buildings /ICSSC Recommended Practice 8 (RP 8)," December 2011.

## Miscellaneous References

[1] Adams, T.M., et al, "A Proposed Procedure for Buried Safety Related Piping at Nuclear Power Facilities," Presented at the 1998 ASME PVP Conference, San Diego, CA, 1998.

[2] American Institute of Chemical Engineers, "Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs," Center for Chemical Process Safety (CCPS), 1994.

[3] Antaki, G., "A Review of Methods for the Analysis of Buried Pressure Piping," Welding Research Council (WRC) Bulleting 425, New York, New York, September 1997.

[4] Bowen, B., "Los Alamos Climatology," Report No.: LA-11735-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, May 1990.

[5] Brookhaven National Laboratory (BNL), "Seismic Design and Evaluation Guidelines for the DOE High-Level Waste Storage Tanks and Appurtenances," K.Bandyopadhyay et al, BNL Report No.: BNL-52361, October 1995.

[6] Cuesta, I., "Design-Load Basis for LANL Structures, Systems, and Components," LANL Report No.: LA-14165, September 2004.

[7] URS Corporation Seismic Hazards Group, "Update of the Probabilistic Seismic Hazard Analysis and Development of Seismic Design Ground Motions at the Los Alamos National Laboratory," prepared for Los Alamos National Laboratory, Job No. 24342433, 2007, LA-UR-07-3965, 25 May 2007.

[8] Lawrence, E., "Site-Specific Extreme Rainfall and Snow Hazard Curves at Los Alamos National Laboratory, Los Alamos, New Mexico," LANL Report No. LA-UR-06-6357, September 2006.

[9] LANL Calculation SB-DO: CALC 08-038, 10/8/08 (derives spectra from URS report LA-UR-07-3965)

[10] LANL Calculation SB-DO: CALC-09-024, Rev. 0, 10/19/09, "Development of TA-55 Structural Design Response Spectra."