Standards

MSC-STD-ENG-097

MSC Engineering Design Codes, Standards and Site Specific Design Parameters

Revision 0, Change 0

Published: 12/15/2015
Effective: 12/15/2015

Program: Engineering
Topic: Engineering

Subject Matter Expert : Dodd, Edwin
Alternate Subject Matter Expert : Ryan, Grant
Functional Manager: Ryan, Grant

Use Type: BAP-Business Administration Procedure

Approved for Public Release;
Further Dissemination Unlimited

JHA:
Periodic Review Due Date: 12/15/2020
Publication Correction: 12/21/2015
Rev. 0, Chg. 0
USQ Screen Number:

CHANGE SUMMARY

Description of Change

This is a complete revision and initial release.

MSC Engineering Design Codes, Standards and Site Specific Design Parameters

Table of Contents

Table of Figures and Tables 2
1.0 PURPOSE....3
2.0 SCOPE....3
3.0 IMPLEMENTATION....4
4.0 APPROACH....4
4.1 General Design Criteria 4
4.2 Safety Performance Category Correlation 4
4.3 Anchorage of Equipment 5
4.3.1 Equipment Seismic Qualification....5
4.3.2 Equipment Seismic Anchorage 6
4.4 Requirements for Ecology Blocks....8
4.4.1 Existing Condition 8
4.4.2 Future (New) Condition 8
4.5 Design Loads 8
4.5.1 Dead loads....9
4.5.2 Live loads....9
4.5.3 Snow loads 10
4.5.4 Wind loads 10
4.5.5 Earthquake loads....11
4.4.6 Ashfall loads....12
4.4.7 Flood loads 13
4.4.7.1 Local Storm Runoff 13
4.4.7.1 Stream Flooding....13
4.4.8 Earth and groundwater pressures 14
4.4.9 Thermal forces....14
4.4.9.1 Ambient Temperatures 15
4.4.10. Creep and shrinkage forces 15
4.5 Design Acceptance Criteria 16
4.6 Foundations 16
4.7 Subsurface Investigations....16
5.0 FORMS 17
6.0 RECORD IDENTIFICATION 17
7.0 REFERENCES 17
APPENDIX A....20
APPENDIX B....23

Table of Figures and Tables

Table 1 Safety Performance Category 5
Table 2 Applicable Requirements for Architectural, Mechanical and Electrical Components Supports and Attachments 6
Table 3 Anchorage of Equipment 7
Table 4 Wind Load and Missile Criteria 10
Table 5 PCI/SDCI and PC2/SDC2 Seismic Design Parameters 11
Table 6 Structural Loads & Airborne Concentration Due to Ash Fallout 12
Table 7 Design-Basis Precipitation Levels 13
Table 8 Columbia River Flood Elevations 13
Table 9 Temperature Ranges for Subsurface System Operation 15

1.0 PURPOSE

The purpose of this MSA Engineering Standard is to provide the engineering design criteria, codes, and standards applicable to MSA facility modifications and new projects. This document has been developed consistent with the current DOE orders, guides, standards and the national consensus standards. This document implements the applicable portion of DOE O 420.1C, *Facility Safety* and provides a general list of the key applicable consensus codes and standards for MSA design activities. This document and the information it contains is intended as a starting point for use by a qualified engineer assigned to the activity, or by the contracted organization.

2.0 SCOPE

Execution of MSA Engineering design activities will be performed in accordance with the applicable requirements. This document provides a summary table (Appendix B) of the key consensus codes and standards applicable to MSA design activities. Design engineers will consider the codes and standards identified in Appendix B for all MSA design activities.

In addition to the identification of the general consensus codes and standards applicable to MSA design work, this document provides a detailed discussion for the implementation of the applicable requirements related to natural phenomena hazards (NPH). Design engineers will consider the applicable elements of the NPH requirements for their design project in accordance with this document. The users must be familiar with and have a working knowledge of the International Building Code (IBC) 2012, DOE-STD-1020-2012, the American Society of Civil Engineers (ASCE) 7-10, *Minimum Design Load for Buildings and Other Structures*. They should also be familiar with and have a working knowledge of national codes and standards applicable to the design, materials, construction, and function of systems.

This information applies to design work initiated for any building acquisition; new or existing facility; facility addition and alteration; leased facilities including onsite constructed buildings, pre-engineered buildings, plant-fabricated modular buildings, mobile offices, trailers; and temporary facilities. The information also applies to movable-skid and wheel-mounted equipment and maintenance and construction equipment.

The use of this information does not preclude the proper evaluation of other structural loads or stress-inducing phenomena such as stability, settlement, and differential motions. If situations arise where these criteria are inadequate, alternate criteria may be used when justified.

NOTE: *Definitions of terms and commonly used acronyms are in Appendix A of this document.*

The scope of this document is limited based on the scope of MSA activities. MSA does not own or operate nuclear facilities in its current work scope; therefore, the criteria applicable to safety systems

are only included in this document the extent necessary to facilitate understanding of the categories. If support has been requested on a safety related system or a system that for any reason needs or may need to be designed to higher level criteria contact the MSA Chief Engineer for direction.

3.0 IMPLEMENTATION

This standard is available for use upon publication.

4.0 APPROACH

4.1 General Design Criteria

Systems shall be designed and evaluated in accordance with the applicable DOE Orders, Standards, Guides, and consensus standards. Appendix B provides a summary list of the key applicable national consensus codes and standards for MSA design activities. All MSA design activities shall consider these codes and standards or their successors as a minimum based on their applicability to the design project.

The IBC and ASCE 7-10 shall be used as the minimum basic design requirements for DOE facilities as applicable to the appropriate PC or SDC outlined in Table 1.

4.2 Safety Performance Category Correlation

For design purposes and the application of these criteria, the design loads and acceptance criteria for systems shall be correlated to PC or Seismic Design Category and Limit State designations. The correlation between the performance categories in DOE-STD-1020-2012 and the corresponding safety classification of systems is shown in Table 1.

NOTE: *Correlation between performance category of DOE-STD-1020-2012 and Safety Classification (per DOE- STD-1021) is as follows:*

- General Services (PC 1)
- Safety Significant (PC 2)
- Safety Class (PC 3)

Table 1 Safety Performance Category

Structures, Systems, Components, Safety Designation and Mitigating Features	Safety Class		Safety Significant			General Services	
	Performs or preserves reactor safety function	Prevents or mitigates rad. consequences above risk guidelines to:	Prevents or mitigates toxic chemical or onsite rad. consequences above risk guidelines to:		Worker safety. Prevents or mitigates serious injury not controlled by ISP to:	Occupant and worker safety controlled by building code and ISP	
		Offsite public	Offsite public (toxic only)	Onsite worker (rad. & toxic chemical)	Facility worker	Any occupant	No occupant
	SC-1			SC-2	SC-3	Non-safety Class	
Performance Category	PC4	PC3		PC2		PC1	PC0
	Goal $1x10^{-5}$	Goal $1x10^{-4}$		Goal $5x10^{-4}$		Goal $1X10^{-3}$	No Goal

4.3 Anchorage of Equipment

Seismic qualification and anchorage of systems shall comply with the appropriate codes as outlined in Table 2.

4.3.1 Equipment Seismic Qualification

Seismic adequacy may be determined by analysis, testing, or the use of seismic experience data. Seismic adequacy determined through the use of seismic experience data is likely to be more economical. Use of experience-based methods requires that adequate engineering analysis be performed by qualified, trained personnel to determine similitude of the equipment items to those available in the experience database. Seismic qualification of safety equipment are subject to the criteria and limitations given in ASCE 43-05 and DOE/EH-0545.

The use of seismic experience data methodology is not a "cookbook" approach because it requires an extensive use of judgment and a thorough understanding of the basis for the methodology. Peer review is a vitally important component of seismic evaluations of equipment and distribution systems at DOE facilities.

4.3.2 Equipment Seismic Anchorage

Anchorage for new PC1/SDC1 and PC2/SDC2 systems and components using expansion anchors shall use any industry standard wedge-type expansion anchor having capacities published by the International Code Council Evaluation Service (ICC-ES) and approved for resistance to wind and seismic loading. The ICC evaluation reports provide pullout strength values for installation in uncracked and cracked concrete. Unless otherwise specified in the design documentation, the values for cracked concrete shall be used.

Table 2 Applicable Requirements for Architectural, Mechanical and Electrical Components Supports and Attachments

(Source: Table 13.2-1 ASCE 7-10)

Nonstructural Element (i.e., Component, Support, Attachment)	General Design Requirements (Section 13.2)	Force and Displacement Requirements (Section 13.3)	Attachment Requirements (Section 13.4)	Architectural Component Requirements (Section 13.5)	Mechanical and Electrical Component Requirements (Section 13.6)
Architectural components and supports and attachments for architectural components	X	X	X	X	
Mechanical and electrical components with Ip > 1	X	X	X		X
Supports and attachments for mechanical and electrical components	X	X	X		X

Anchorage for PC1/SDC1 systems and components (source) that are within the zone of influence of a PC2/SDC2, or PC3/SDC3 item (target) and whose structural failure may compromise the structural integrity of the target to perform its safety function shall be designed by using the methods of ASCE 7-10 and the loading for the target, except for the number of directions of applied seismic loading. The seismic loading shall be applied in three orthogonal directions. The three orthogonal directions can be combined by either the square-root-of-the- sum-of-the-squares (SRSS) or by assuming 100 percent of the seismic load acts in one primary lateral direction and 40 percent of the peak seismic load acts simultaneously in the other two orthogonal directions. The primary lateral acceleration shall be applied to produce the most severe anchorage loads.

Anchorage of existing systems and components using expansion anchors, cast-in-place bolts (j-bolts, headed studs, etc.) and grouted-in-place bolts shall use allowable bolt capacities from

HNF-SD-GN-DGS-30006, *Guidelines for Assessing the Seismic Adequacy of Existing Performance Category Equipment at the Hanford Site*.

Anchorage documentation shall comply with Table 3 by using the requirements for the source where interaction occurs.

Table 3 Anchorage of Equipment

DOE-STD-1020 performance category	PC4	PC3	PC2	PC1
Permanent Equipment	(1)	(1)	(1)	(1)
Temporary or Movable Equipment	(1)	(1)	(1)	(2)(3)

NOTE 1: *Equipment shall be anchored to resist overturning, sliding, and possible floating. Equipment anchorage shall be designed to resist the total design lateral force without benefit from the use of friction that results from gravity loads. Friction that results from overturning forces or from clamping forces may be used. Anchorage for PC1/SDC1 equipment, whose failure would cause a life hazard or compromise safe access or egress from the facility, shall be designed by using the methods (and the importance factor of 1.5) in ASCE 7-10 for life-safety systems. The PC1/SDC1 floor- or roof-mounted equipment weighing less than 181 kg (400 lb.), whose failure does not cause a life hazard or compromise safe access or egress from a facility is exempt from anchorage or restraint requirements. The evaluation shall be documented.*

NOTE 2: *The PC1/SDC1 equipment whose failure would cause a life hazard or compromise safe access or egress from a facility shall be anchored, restrained, or shown to be stable such that the equipment item would not overturn, slide, or float. Anchorage of equipment whose failure would cause a life hazard or compromise safe access or egress shall be designed by using the methods (and the importance factor of 1.5) in ASCE 7-10 for life-safety systems. Equipment shall be anchored as in item 1, above, unless it is shown by analysis that the equipment will not overturn. Items shown by analysis <u>not</u> to be vulnerable to overturning shall be restrained from sliding, unless it can be shown by analysis that the lateral movement of the item is acceptable. Items shown by analysis <u>not</u> to be vulnerable to overturning and whose lateral movement has been shown to be acceptable may be unrestrained. Friction that results from gravity loads (with appropriate reductions for vertical seismic accelerations or uplift forces) may be used to limit lateral movement of unrestrained equipment. The maximum lateral movement should be estimated and included in the design of rattlespace (space allowed for motion such as sliding) and utility connections. Floor- or roof- mounted equipment weighing less than 181 kg (400 lb), furniture, and temporary or movable PC1/SDC1 equipment whose failure does not cause a life hazard or compromise safe access or egress from a facility is exempt from anchorage or restraint requirements. The evaluation shall be documented.*

NOTE 3: *PC1/SDC1 equipment that does not pose a threat to life safety is exempt from anchorage or restraint requirements. However, the expense or procurement time to replace unanchored equipment that may be damaged should be considered in the decision to have the equipment unanchored.*

4.4 Requirements for Ecology Blocks

4.4.1 Existing Condition

- Prior to lifting or stacking of existing Ecology Blocks, that do not have documented engineering, inspection and lift plan shall be developed.
- Existing Ecology Blocks stacked more than two high shall be evaluated for structural stability.

4.4.2 Future (New) Condition

- Ecology Blocks shall be designed by a licensed professional engineer. Concrete shall be per ACI 318 and 301. Lifting bails shall be grade 60 steel per ASTM A615 or ASTM A 706 or Wire Rope per ASTM A 603. Ecology Blocks bails shall be load test to 125%. Each concrete ecology block shall be permanently marked (etched or stenciled) on both sides of the block with the Contract Number and the month and year of fabrication.
- Ecology Blocks stacked more than two high shall be evaluated for structural stability.

4.5 Design Loads

Design loads are applied by using a graded approach, depending on the safety designation and PC of the systems considering:

- Dead loads,
- Live loads,
- Snow loads,
- Wind loads,
- Earthquake loads,
- Volcanic ash fall loads,
- Flood loads,
- Earth and groundwater pressure loads,
- Thermal loads,
- Concrete creep and shrinkage loads,
- Lightning.

4.5.1 Dead loads

Dead loads include the weights of all permanent materials and equipment, including the structures own weight. Design dead loads shall include the weight of all permanent service equipment. Service equipment shall include plumbing stacks, piping, heating and air-conditioning equipment, electrical equipment, flues, fire sprinkler piping and valves, and similar fixed furnishings. Load calculations shall include an allowance for any loadings anticipated to be added at a later date. Initially assumed loads shall be revised so that the final design reflects the configuration shown on the drawings.

The minimum allowance for the weights of partitions, where partitions are not likely to be rearranged or relocated, shall be as follows:

- For partition weights of 220 kg/m (150 lb/ft) or less, an equivalent uniform dead load of 960 Pa (20 lb/ft^2) shall be used.
- For partition weights above 220 kg/m (150 lb/ft), the actual linear loads shall be used.

The unit weights of materials and construction assemblies for buildings and other structures shall be those given in ASCE 7-10. Where unit weights are neither established in that standard nor determined by test or analysis, the weights shall be determined from data in manufacturer drawings or catalogs. The unit weights of materials for highway structures shall be those given by AASHTO standards. The unit weights for railway structures shall be those given in the *AREMA Manual for Railway Engineering*.

4.5.2 Live loads

Live loads are those loads produced by the use and occupancy of the building or other structure and do not include construction and environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. Live loads on a roof are produced by maintenance workers and equipment and within a structure by partitions, people, and office equipment.

- Live loads for buildings and other structures shall be not less than the minimum uniform load or concentrated load stipulated in ASCE 7-10.
- The minimum roof design live load shall be 960 Pa (20 lb/ft^2).
- The weight of service equipment that may be removed with change of occupancy of a given area shall be considered as live load.
- Partitions that are likely to be rearranged or relocated shall be calculated as live loads.
- Live loads for highway structures shall also comply with AASHTO HB-16, *Standard Specifications for Highway Bridges*. Unless specified otherwise, an HS 20-44 loading shall be used.

- Live loads for railway structures shall also comply with AREMA Manual for Railway Engineering. Unless specified otherwise, a Cooper E-80 loading shall be used.

4.5.3 Snow loads

Snow loads, full or unbalanced, shall be substituted for roof live loads in Section 4.4.2, where such loading results in larger members or connections. Snow loads for buildings and other structures shall be in conformance with ASCE 7-10. A ground snow load, P_g, of 720 Pa (15 lb/ft^2) shall be used for calculating roof snow load. Unbalanced snow loads resulting from drifting or sliding shall be considered.

4.5.4 Wind loads

The structural frame and exterior components of all buildings, signs, tanks, towers, and other exposed structures including movable equipment shall be designed to resist pressures from wind from any direction. Partial wind loading shall be considered if it produces a more severe effect. Design basis tornadoes are not applicable to nonreactor nuclear or nonreactor non- nuclear systems on the Hanford Site (see HNF-SD-GN-ER-501, Rev. 2, *Natural Phenomena Hazards, Hanford Site, Washington*).

Wind design categorization (WDC) and wind load design for buildings and other structures shall comply with DOE-STD-1020-2012 and ASCE 7-10 and the wind parameters outlined in Table 4.

Table 4 Wind Load and Missile Criteria

	PC2/WDC2	**PC1/WDC1**
(ASCE 7-10) Ultimate Design Wind Speed (peak gust)	51 m/s (115 mph)	49 m/s (110 mph)
(ASCE 7-05) Nominal Design Wind Speed (peak gust)	41 m/s (91 mph)	38 m/s (85 mph)
Exposure Category	C	C
Missile (horizontal)	N/A	N/A
DOE-STD-1020-2012 Annual Exceedance Probability	$1x10^{-2}$	$1x10^{-2}$
ASCE-7-10 Annual Exceedance Probability	$5.88x10^{-4}$	$1.43x10^{-3}$

NOTE: *Wind speed limit in ASCE 7-10 corresponds to the rounded value from the following relationship: VASCE7-05 (asd) = VASCE7-10 (ult) √0.6 (IBC 2012 Equation 16-33)*

The wind pressure increase resulting from nearby terrain features (wind speed up over hills and escarpments), building torsion produced by wind, and biaxial wind loading of buildings are effects that must be structurally investigated as described in ASCE 7-10.

Design for higher wind pressures shall be considered for locations subject to unusual wind velocity such as the top of Rattlesnake Mountain where winds of approximately 72 m/s (160 mi/h) have been estimated.

Building additions shall be designed as parts of a totally new building without regard to shielding from the original building and without regard to lesser wind resistance for which the original building may have been designed. The possibility that the original portion of the building may require strengthening because of an increase in the wind loads acting on it shall be considered.

The wind loads for highway structures shall also comply with AASHTO. The wind loads for railway structures shall also comply with AREMA Manual for Railway Engineering.

4.5.5 Earthquake loads

PC1/SDC1 and PC2/SDC2 structures, systems, and components

Earthquake load design of PC1/SDC1 systems shall comply with the IBC/ASCE 7, for standard occupancy facilities. Earthquake load design of PC2/SDC2 systems shall comply with the IBC/ASCE 7, for essential facilities. Seismic design parameters for PC1/SDC1 and PC2/SDC2 are given in Table 5.

Table 5 PCI/SDCI and PC2/SDC2 Seismic Design Parameters

PC/SDC	PC1/SDC1	PC2/SDC2
Site Class*	D	D
S_S	0.46	0.46
S1	0.15	0.15
Importance Factor (IP)	1.0	1.5

* Site Class C may be used, if soil properties are known

4.4.6 Ashfall loads

Volcanic design categorization (VDC) and design consideration for volcanic hazards are defined in DOE-STD-1020-2012. New structural loads due to ash fallout are shown in Table 6 (For derivation of volcano ashfall loads to be used on the Hanford Site, See WHC-SD-GN-ER-30038, Rev. 2 and HNF-SD-GN-ER-501, Rev. 2)

Table 6 Structural Loads & Airborne Concentration Due to Ash Fallout

PC/VDC	Annual Exceedance Probability	Ashfall Load(1) kg/m^2 (PSF)	Airborne Concentration (Initial) g/m3	Airborne Concentration (Resuspended) g/m3	Momentary Peak Ash Concentrations g/m3
1	1×10^{-3}	15.62 (3.2)	0.2	0.16	0.370
2	5×10^{-4}	57.61 (11.8)	0.8	0.6	1.325

(1) Dry basis. When not considered in combination with snow load, an additional 0.5 psf moisture load applies.

For the design and evaluation of PC-1/VDC-1 and PC-2/VDC-2, the load combinations in ASCE 7-10 shall be used substituting the ash load, V, for the snow load, S, in the load combinations.

The ashfall load on an unobstructed flat roof shall be equal to the ground loading. All ashfall loads on a sloping roof should be considered to act on the horizontal projection of that roof. Unbalanced ashfall loads resulting from drifting or sliding shall be considered.

Momentary Peak Ash Concentrations (Table 6) shall be considered for facilities that require active safety components to operate throughout and following an ashfall event. There would be a general alert of an impending eruption because of increased seismicity at the volcano from days to years prior to ashfall at the Hanford Site. The actual volcano eruption would precede any ashfall at the Hanford Site by greater than 2 hours.

4.4.7 Flood loads

Flood design for buildings and other structures and flood design categories (FDC) shall comply with DOE-STD-1020-2012.

4.4.7.1 Local Storm Runoff

Design-basis 6-hour precipitation levels are shown in Table 7.

Table 7 Design-Basis Precipitation Levels
(Source: Table 3, HNF-SD-GN-ER-501, Rev. 2)

PC/FDC	Probability	Amount (in.)
1	2×10^{-3}	1.8
2	5×10^{-4}	2.5

4.4.7.1 Stream Flooding

The Columbia River flood stage elevation are obtained from Table 8.

Table 8 Columbia River Flood Elevations
(Source: Figure 5, HNF-SD-GN-ER-501, Rev. 2)

Location	River Kilometer (Mile)	PC3/FDC3 Flood Stage Elevation	PC2/FDC2 Flood Stage Elevation	PC1/FDC1 Flood Stage Elevation
None, for reference only	631 (392)	143.3 (470)	137.2 (450)	132.6 (435)
100 B Area	618 (384)	140.2 (460)	132.6 (435)	128.0 (420)
100 K Area	615 (382)	138.7 (455)	131.0 (430)	125.9 (413)
100 N Area	612 (380)	137.2 (450)	128.6 (422)	125.6 (412)
100 D Area	607 (377)	135.6 (445)	127.4 (418)	125.0 (410)
100 H Area	599 (372)	134.1 (440)	126.5 (415)	121.9 (400)
100 F Area	594 (369)	134.1 (440)	126.5 (415)	121.3 (398)
None, for reference only	579 (360)	131.0 (430)	121.9 (400)	118.3 (388)
300 Area	554 (344)	120.4 (395)	115.8 (380)	112.2 (368)

NOTE: *Elevations in feet above mean sea level 1 foot (feet) = 0.305 m; 1 mile = 1.62 km*

The 200 Areas and the 400 Area are approximately 60 m (200 ft) above the Columbia River at its nearest flood inundation point. These areas are dry sites and need not consider Columbia River flooding in design for any PC.

4.4.8 Earth and groundwater pressures

Every foundation wall or other wall serving as a retaining structure shall be designed to resist (in addition to the vertical loads acting on it) the incident lateral earth pressures and surcharges, plus hydrostatic pressures corresponding to the maximum probable groundwater level.

The PC1 and PC2 below grade structures are not required to be evaluated for dynamic soil loads. A minimum soil density of 110 lbf/ft^3 should be used for PC1 structures and may be used for PC2 structures until the subsurface soil investigations are completed.

For PC1 structures, the allowable soil bearing pressure from the IBC may be used for design where precise soil-bearing information is not available. These values are considered to be acceptable for undisturbed earth.

Lateral earth pressures for PC1 and PC2 structures shall be as follows unless site-specific soil conditions have been determined from subsurface investigations. Site-specific soil conditions shall be used when known.

- Cantilever or other flexible walls exposed to earth fill shall be designed for a static equivalent fluid pressure of 1,440 Pa (30 lbf/ft^2), based on an active earth pressure coefficient, K_a, of 0.27 and soil density of 1,760 kg/m^3 (110 lbf/ft^3).

- Basement or other rigid walls exposed to ordinary compacted backfill shall be designed for a static equivalent fluid pressure of 2,640 Pa (55 lbf/ft^2), based on an at-rest earth pressure coefficient, K_o, of 0.50 and a soil density of 1,760 kg/m^3 (110 lbf/ft^3).

- Rigid walls exposed to backfill compacted to at least 75% of relative density shall be designed for 3,690 Pa (77 lbf/ft^2), based on a k_o of 0.70 and a soil density of 1,760 kg/m^3 (110 lbf/ft^3).

- Superimposed lateral pressures resulting from uniform surcharge loadings shall be calculated by using appropriate earth pressure coefficients as shown above. Resultant forces from point and line loads shall be added.

4.4.9 Thermal forces

The design of structures shall include the effects of stresses and movements resulting from variations in temperature. Structures shall be designed for movements resulting from the maximum seasonal temperature change. The design shall provide for the lags between air temperatures and the interior temperatures of massive concrete members or structures. Consideration shall be given to passive soil loading resulting from thermal growth of subgrade structures.

4.4.9.1 Ambient Temperatures

Systems in all performance/design categories should be designed to operate in an ambient temperature range of 115°F to -25°F.Subsurface Temperature

For purposes other than frost and freeze protection, systems in all performance categories should be designed for subsurface temperature ranges as shown in Table 9.

Table 9 Temperature Ranges for Subsurface System Operation

(Source: Figure 5, HNF-SD-GN-ER-501, Rev.2)

Depth	Design Temperature Range
0.5 inches	160°F to -25°F
15 inches	95°F to 10°F
36 inches	87°F to 30°F

4.4.10. Creep and shrinkage forces

Concrete and masonry structures shall be investigated for stresses and deformations induced by creep and shrinkage. For concrete and masonry structures, the minimum linear coefficient of shrinkage shall be assumed to be 0.0002 mm/mm, unless a detailed analysis is undertaken. The theoretical shrinkage displacement shall be computed as the product of the linear coefficient and the length of the member.

4.4.11. Lightning

Protection from lightning shall be considered for all systems. The PC, human occupancy, and economic value of the systems shall be considered when developing appropriate protection. Design of lightning protection shall consider NFPA 780, *Lightning Protection Code*.

4.4.12. Load factors and load combinations

Load factors, load combinations, allowable stresses, and strength requirements for PC1/SDC1 and PC2/SDC2 structures, systems, and components shall comply with the IBC and ASCE 7 or applicable system national codes and standards. Load combinations include live load, dead load, snow load, and normal operating loads for all systems.

Combination of loads and design requirements for highway structures shall comply with AASHTO HB-16.

Combination of loads and design requirements for railway structures shall comply with AREMA Manual for Railway Engineering.

4.5 Design Acceptance Criteria

Guidance for selecting codes and standards that are necessary for the performance or maintenance of the safety function of systems as identified by the safety analysis and associated documents is in Appendix B.

4.6 Foundations

Foundations shall comply with the IBC. The potential adverse effects of frost heave and movements resulting from expansive soils shall be considered in the design.

The bottom of foundations of permanent structures (except elevated tanks and stacks) shall be at least 0.6 m (24 in.) below finished grade and shall bear on undisturbed earth or on properly compacted backfill that has bearing capacity sufficient to meet design requirements.

The bottom of foundations supporting elevated tanks and stacks shall be at least 1.2 m (4 ft) below finished grade and shall bear on undisturbed earth or on properly compacted backfill that has bearing capacity sufficient to meet design requirements.

Heavy, vibration-producing equipment, such as high-pressure air compressors, chillers, fire pumps, and engine/generator sets, shall have separate, isolated foundations.

All shoring and underpinning shall comply with the safety requirements of the *Washington Administrative Code*, WAC 296-155, Part N.

The services of a structural engineer specializing in underpinning shall be used to perform any underpinning design.

4.7 Subsurface Investigations

Subsurface investigations shall be made for PC2/SDC2 structures. For permanent structures, subsurface conditions shall be determined by means of bore holes or other methods that adequately disclose soil and groundwater conditions. Data and other information obtained from prior subsurface investigations shall be used, supplemented by additional investigations at the specific location as deemed necessary by the structural engineer. For PC1/SDC1 structures, the allowable soil pressure from the IBC may be used for design where precise soil bearing information is not available.

NOTE: *A bibliography and brief summary of geotechnical studies performed at the Hanford Site have been documented in WHC-SD-GN-ER-30009, Bibliography and Summary of Geotechnical Studies at the Hanford Site, May 12, 1992. More recent, area specific, geotechnical studies are also available; such as K East, K West, CVDF, HWVP.*

Subsurface investigations shall be performed under the direction of a qualified soils engineer, licensed by the state to practice as such. Appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure and shall include, but not be limited to, a recommendation of foundation type, determinations of allowable soil bearing design capacity, and the possible effects of seismic activity on the soil mass. A settlement analysis under differential design loads shall be performed where differential settlement may cause structural or architectural damage.

5.0 FORMS

None

6.0 RECORD IDENTIFICATION

None

7.0 REFERENCES

AASHTO, *American Association of State Highway and Transportation Officials*

ACI 301, *Specifications for Structural Concrete*

ACI 318, *Building Code Requirements for Structural Concrete*

ACI 350.2R, *Concrete Structures for Containment of Hazardous Materials*

ACI 530/530.1, *Building Code Requirements and Specifications for Masonry Structures*

ACI 307, *Code Requirements for Reinforced Concrete Chimneys*

AISC 325-05, Steel Construction Manual 14th Edition

API STD 620, *Design and Construction of Large, Welded, Low-pressure Storage Tanks – 12th Edition*

API STD 650, *Welded Tanks for Oil Storage – 12th Edition*

AREMA, *American Railway Engineering and Maintenance-of –Way Association*

ASCE 7-05 COMBO, *Minimum Design Loads for Buildings and Other Structures*

ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*

ASCE 19-10, *Standard Guidelines for the Structural Applications of Steel Cables for Buildings*

ASCE/SEI 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B31.9, *Building Services Piping*

ASME STS-1, *Steel Stacks*

ASME Y14.38, *Abbreviations and Acronyms for Use on Drawings and Related Documents*

ASTM A603, *Standard Specification for Zinc-Coated Steel Structural Wire Rope*

ASTM A615, *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*

ASTM C635/C635M Rev A, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*

ASTM C636/C636M, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*

ASTM E580/E580M, *Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions*

ASTM A706, *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement*

AWS D1.1/D1.1M, *Structural Welding Code – Steel 23rd Edition*

AWS D1.2/D1.2M, *Structural Welding Code – Aluminum – 6th Edition*

AWS D1.3/D1.3M, *Structural Welding Code – Sheet Steel 5th Edition*

AWS D1.6/D1.6M, *Structural Welding Code – Stainless Steel*

AWWA C110/A21.10, *Ductile-Iron and Gray-Iron Fittings*

AWWA C153/A21.53, *Ductile-Iron Compact Fittings*

AWWA C206, *Field Welding of Steel Water Pipe*

AWWA C504, *Rubber-Seated Butterfly Valves*

AWWA C509, *Resilient-Seated Gate Valves for Water Supply Service*

AWWA C905, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm), for Water Transmission and Distribution*

DOE O 420.1C, *Facility Safety*, Chg 1

DOE-STD-1020-2012, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*

IBC 2012, *International Building Code*

NESC, *National Electrical Safety Code*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 70, *National Electrical Code*

NFPA 70E, *Standard for Electrical Safety in the Workplace*

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*

NFPA 101, *Life Safety Code*

NFPA 780, *Standard for the Installation of Lightning Protection Systems*

HNF-SD-GN-DGS-30006, *Guidelines for Assessing the Seismic Adequacy of Existing Performance Category Equipment at the Hanford Site*, Rev 2 (1997)

HNF-SD-GN-ER-501 Rev. 2, *Natural Phenomena Hazards, Hanford Site, Washington*

PRC-PRO-IRM-10588, *Records Management Processes*

TIA TIA-568.1-D, *Commercial Building Telecommunications Infrastructure Standard*

TIA TIA-569-D, *Telecommunications Pathways and Spaces*

TIA TIA-607-C, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*

WAC 296-155, *Safety Standards for Construction Work*, Part N, *Excavation, Trenching, and Shoring*

WHC-SD-GN-ER-30009, *Bibliography and Summary of Geotechnical Studies at the Hanford* Site (1992)

WHC-SD-GN-ER-30038 Rev. 2, *Volcano Ashfall Loads for the Hanford Site*

APPENDIX A
Glossary

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.

design-basis ashfall: The volcanic ashfall chosen as the basis for the design of structures.

design-basis earthquake: The earthquake ground motion chosen as the basis for the design of structures.

design-basis wind: The wind velocity chosen as the basis for the design of structures.

existing facility: A DOE facility that has received authorization to operate on or before the effective date of the requirement, or if authorization is not required, a DOE facility that has begun normal operation on or before the effective date of the requirement.

facility: One or more building(s) or structure(s), including systems and components, dedicated to a common function (includes operating and nonoperating facilities and facilities slated for decontamination and decommissioning).

interaction: The potential damage and failure of structures, systems, and components because of both direct natural phenomena hazard effects and response of adjacent structures, systems, and components.

natural phenomena hazard: 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: A DOE facility that does not qualify as an existing facility.

response spectrum (spectra): Seismic input for the dynamic evaluation of structures, systems, and components. A response spectrum is the relationship between the natural frequency of vibration and the acceleration, velocity, or displacement response of a simple oscillator. It shows amplified response of flexible structures, systems, and components.

shall: Denotes a requirement.

shall consider: Requires that an objective assessment be performed to determine to what extent the criterion will be incorporated into or satisfied by the design. The results and basis of this assessment shall be documented and retrievable and may be in the form of engineering studies, meeting minutes, reports, internal memoranda, etc.

should: Denotes a recommendation.

structures, systems, and components: A structure is an element or a collection of elements to provide support or enclosure (such as a building, free-standing tank, 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 equipment (such as a pump, valve, or relay, or an element of a larger array such as a length of pipe, elbow, or reducer).

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASME	American Society of Mechanical Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
DOE	U.S. Department of Energy
DOE-STD	U.S. Department of Energy, Standard
IBC	International Building Code
MBMA	Metal Building Manufactures Association
NTIA	National Telecommunications and Information Administration
NFPA	National Fire Protection Association
NPH	natural phenomena hazard
PC	performance category
SDI	Steel Door Institute
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors’ National Association

APPENDIX B
Guidance For Selecting National Codes And Standards

The most common national consensus codes and standards applicable to the design and quality requirements for systems, based on their safety classification, are listed in Table B-1. This table is provided as a starting point for the identification of the appropriate codes and standards and has been graded based on the applicable MSA scope. In addition to the listed codes the engineer(s) responsible for the design need to consider other sources including but not limited to the Revised Code of Washington (RCW).

When applying design criteria to a system, its safety classification (importance to safety) and safety function (design attributes) should be considered. Design and quality requirements are derived from national consensus codes and standards. There are two groups of these national codes and standards: those that provide for general industry and those that provide specifically for the commercial nuclear industry. The codes and standards for general industry are specific to the type of equipment and may even specify application according to equipment use in broad categories of facility type. The codes and standards for the commercial nuclear industry are specific to the equipment and the safety functions performed by the equipment.

Table B-1 correlates general industry and nuclear industry codes and standards based on safety classification. Select those codes and standards that are necessary for the safety function as identified by the safety analysis and associated documents. These codes and standards should be considered for guidance where codes and standards are not specified in Section 4.0 of this document, other codes and standards may also apply.

Table B-1 – Guidance For Selecting National Codes and Standards

Design Category	(PC1/SDC1)	(PC2/SDC2)
Structural – Steel	IBC; AISC-325	Same as PC1
Steel Cables for Buildings	ASCE 19-10	Same as PC1
Steel Decks	SDI	Same as PC1
Steel Joists	SJI	Same as PC1
Welding	AWS D1.1/D1.1M; AWS D1.2/D1.2M; AWS D1.3/D1.3; AWS D1.6	Same as PC1
Light-gauge Steel	AISI	Same as PC1
Pre-Engineered Metal Buildings	MBMA	Same as PC1
Structural Concrete	IBC; ACI-318 CD	Same as PC1
Sanitary Engineering Concrete Structures	ACI 350.2R	Same as PC1
Structural – Masonry	IBC; ACI 530/530.1	Same as PC1
Structural – Wood	IBC	Same as PC1
Access Flooring	IBC	Same as PC1

Design Category	(PC1/SDC1)	(PC2/SDC2)
Ceiling Suspension Systems	IBC; ASTM C 635/C635M Rev A; ASTM C 636/C636M; ASTM E580/E580M	Same as PC1
Highway Structures	AASHTO HB-16	Same as PC1
Railway Structures	AREMA Manual	Same as PC1
Towers and poles	NTIA Manual	Same as PC1
Chimneys and Stacks	ACI 307; ASME STS-1; IBC	Same as PC1
Ducts	SMACNA Manual	Same as PC1
Fans	ASHRAE Handbook	Same as PC1
Filtration	ASHRAE Handbook	ASHRAE-52.1; Mil-F-51068F; ASME-N509 and N510; DOE NE STD-F3-45
Pressure Vessels	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2	Same as PC1
Tanks (0 – 15 psig)	API-620;ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2	Same as PC1
Tanks (containing flammable liquids)	API STD 620; API-STD-650; NFPA 30	Same as PC1

Design Category	(PC1/SDC1)	(PC2/SDC2)
Roads	http://www.wsdot.wa.gov/Business/ ; M 41-10, Division 5, Surface Treatments and Pavements, Section 5-04, Hot Mix Asphalt, p 17-33, http://www.wsdot.wa.gov/publications/manuals/fulltext/ M41-10/SS2012.pdfMaterialsLab/Pavements/PavementDesign.htm; http://www.wsdot.wa.gov/NR/rdonlyres/D7971B81-5443-45B9-8B9B-BFC0D721F5A1/0/WSDOTPavementPolicyFinal71211.pdf; http://www.wsdot.wa.gov/LocalPrograms/LAG/HMA.htm; http://www.transportation.org/Pages/Default.aspx	Same as PC1
Piping:	ASME B1.20.1; ASME B31.9; ASME Code Section V; ASME Y14.38;	Same as PC1
Water Works	AWWA C110/A21.10; AWWA C153/A21.53; AWWA C206; AWWA C504; AWWA C509; AWWA C905	Same as PC1
Telecommunications	ANSI/TIA/EIA-568; ANSI/TIA/EIA-569; ANSI/TIA J-STD-607-B	Same as PC1
NFPA General Building Design Codes (see MSC-RD-FP-10606, *Fire Protection Program Requirements* for additional guidance regarding FP program requirements)	NFPA 70; NFPA 70E; NFPA 90A; NFPA 101; NFPA 780	Same as PC1

Design Category	(PC1/SDC1)	(PC2/SDC2)
Electrical Design	NESC	Same as PC1

NOTE: This table is provided as a starting point for the identification of the appropriate codes and standards and has been graded based on the applicable MSA scope. In addition to the listed codes the engineer(s) responsible for the design need to consider other sources including but not limited to the Revised Washington Code (RWC).

For reference document titles see Section 8.0.
For acronyms and abbreviations see Appendix A.