CPCCo Central Plateau Cleanup Company

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Administrative Procedure, Level 1 - Company Wide

CPCC-PRO-EN-097

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Engineering Design and Evaluation (Natural Phenomena Hazard)

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendixes

1.0 INTRODUCTION

1.1 Purpose

This procedure implements the current U.S. Department of Energy, Richland Operations Office (DOE-RL), requirements for both general design criteria and natural phenomena hazard (NPH) mitigation for the Hanford site as identified in DOE O 420.1C, *Facility Safety,* DOE STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities* and Correspondence No.2201360 (DOE-RL:22-NSD-000508), *CONTRACT NO. 89303320DEM000030-ALIGNMENT WITH THE WASHINGTON STATE ADOPTION OF THE 2018 VERSION OF THE INTERNATIONAL BUILDING CODE.*

Guidance for implementing the requirements of DOE O 420.1C is provided in DOE G 420.1-1A, *Nonreactor Nuclear Safety Design for use with DOE O 420.1C, Facility Safety*.
DOE-STD-1020-2016 provides NPH design and evaluation criteria for earthquake, wind, ashfall, and flood hazards based on design categories (DCs), replacing the performance categories (PCs) in DOE-STD-1020-2002.

DOE-STD-1020-2016 provides seismic design and evaluation criteria based on Seismic Design Category (SDC) and Limit State as outlined in ANSI/ANS 2.26-2004, Categorization of Nuclear Facility Structures, Systems and Components for Seismic Design; and ASCE/SEI 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities.

This document defines the minimum criteria for structural design and evaluation of structures, systems, and components (SSCs). The structural design loads and structural acceptance criteria are established to design new SSCs, to evaluate existing SSCs, to evaluate anchorage effects of new and modified systems on existing SSCs, and to design additions and modifications to existing SSCs.

For convenience, pertinent requirements from DOE O 420.1C, DOE G 420.1-1A, DOE-STD-1020-2016, are included. This document does not supersede DOE O 420.1C. Requirements in the DOE order govern if there are inconsistencies.

NOTE: Correspondence No.2201360 (DOE-RL:22-NSD-000508), *CONTRACT NO. 89303320DEM000030-ALIGNMENT WITH THE WASHINGTON STATE ADOPTION OF THE 2018 VERSION OF THE INTERNATIONAL BUILDING CODE* directs the use of IBC-2018.

1.2 Scope

This document is intended for use by experienced engineers in the design of SSCs and are familiar with DOE orders and standards, and with national building codes and standards. The users must be familiar with and have a working knowledge of the International Building Code (IBC) 2018, DOE-STD-1020-2016, the American Society of Civil Engineers (ASCE) 7-16, *Minimum Design Load for Buildings and Other Structures*, and ASCE 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities.* 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 SSCs.

This information applies to design work initiated after **08/31/2022** 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 are in Appendix A and commonly used acronyms are in Appendix B of this document.*

1.3 Applicability

This Engineering Design and Evaluation Procedure shall be applied to all projects managed by Central Plateau Cleanup Company (CPCCo), new CPCCo-managed facilities, all major modifications (as defined in DOE STD 1189, Integration of Safety into the Design Process), and the evaluation of existing facilities.

1.4 Implementation

Effective upon publication.

2.0 RESPONSIBILITIES

Responsibilities are as addressed in Section 3.

3.0 PROCESS

3.1 General Design Criteria

SSCs shall be designed and evaluated to withstand loads associated with the operation of the facility and the effects of NPHs. Design and evaluation of SSCs shall comply with DOE-STD-1020-2016 and the loads and acceptance criteria given in this document. It is the intent of this document to conform to and/or use national consensus codes and standards wherever practical. Applicable national, federal, or industry consensus codes, standards, manuals of practice, or model building codes shall be deemed acceptable to meet the intent of this document.

The IBC 2018, ASCE 7-16, and ASCE 43-05 shall be used as the minimum basic design requirements for DOE facilities as applicable to the appropriate DC or SDC outlined in Table 1.

The SSCs need not be subjected simultaneously to any combination of extreme wind, earthquake ground motions, ashfall, and flood. However, common cause events are to be evaluated as single events; e.g., fires that may erupt following earthquakes.

3.2 Seismic Design Category and Performance Category Correlation

For design purposes and the application of these criteria, the design loads and acceptance criteria for SSCs shall be correlated to PC or Seismic Design Category and Limit State designations. The correlation between the performance categories in DOE-STD-1020-2002 and the seismic design category and limit states in DOE-STD-1020-2016, and corresponding seismic design criteria are shown in Table 1.

NOTE: *Correlation between performance category of DOE-STD-1020-2002 and Safety Classification (per DOE- STD-1021) is as follows:*

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

Table 1 – Seismic Design Category and Performance Category Correlation and Corresponding Seismic Design Criteria

(Source: ASCE 43-05, Table C1-1 & DOE-STD-1020-2016 Table 3-1)

SDC	Limit State			
	A	B	C	D
1	ASCE/SEI 7-16 RC II (I =1.0) R_a = R or R_p **(DOE PC 1)**	ASCE/SEI 7-16 RC II (I =1.0) R_a = (R or R_p) /1.25 $R_a \geq 1.2$	ASCE/SEI 7-16 RC II (I =1.0) R_a = (R or R_p) /1.5 $R_a \geq 1.2$	ASCE/SEI 7-16 RC II (I =1.0) R_a or R_p = 1.2
2	N/A	ASCE/SEI 7-16 RC IV (I =1.5) R_a = R or R_p **(DOE PC 2)**	ASCE/SEI 7-16 RC IV (I =1.5) R_a = R or R_p /1.2 $R_a \geq 1.2$	ASCE/SEI 7-16 RC IV (I =1.5) R_a or R_p = 1.2
3	ASCE 43-05	ASCE 43-05	ASCE 43-05 **(DOE PC 3)**	ASCE 43-05
4	ASCE 43-05	ASCE 43-05	ASCE 43-05	ASCE 43-05
5	ASCE 43-05	ASCE 43-05	ASCE 43-05 DOE PC 4 Near NRC NPP	ASCE 43-05 Similar to modern NRC NPP

RC = Risk Category
I = Importance Factor (Table 1.5-2 of ASCE 7-16)
R or R_p = Response Modification Coefficient given in ASCE 7-16 (Tables 12.2-1, 12.14-1, 13.5-1, 13.6-1, 15.4-1, and 15.4-2 of ASCE 7-16).
Ra = Actual (reduced) Response Modification Coefficient to be used in the design
NPP = Nuclear power plant

ASCE 7-16 Risk Category IV (I = 1.5) shall be used if there is a radiological release consequence of concern to the public or the environment resulting from an unmitigated failure of the SSC.

Table 2 – Importance Factors by Risk Category of Buildings and Other Structures for Snow, Ice, and Earthquake Loads[a]
(Source: Table 1.5-2 ASCE 7-16)

Risk Category From Table 1.5-1	Snow Importance Factor, Is	Ice Importance Factor—Thickness, Ii	Ice Importance Factor—Wind, Iw	Seismic Importance Factor, Ie	[a]Component Seismic Importance Factor, Ip,
I	0.80	0.80	1.00	1.00	1.00
II	1.00	1.00	1.00	1.00	1.00
III	1.10	1.25	1.00	1.25	1.25
IV	1.20	1.25	1.00	1.50	1.50

[a]For details on the component importance factor, Ip, refer to ASCE 7-16, Section 13.1.3.

3.3 Equipment Seismic Qualification and Anchorage

Seismic qualification and anchorage of SSCs shall comply with the appropriate codes as outlined in Table 1.

3.3.1 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, ASME QME-1, *Qualification of Active Mechanical Equipment Used in Nuclear Facilities,* and DOE/EH-0545, *Seismic Evaluation Procedure for Equipment in U.S. Department of Energy Facilities*.

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.

3.3.2 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 3 – Applicable Requirements for Architectural, Mechanical, and Electrical Components Supports and Attachments for PC1/SDC1 & PC2/SDC2

(Source: Table 13.2-1 ASCE 7-16)

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	X	X	X		X
Supports and attachments for mechanical and electrical components	X	X	X		X

Anchorage for new PC3/SDC3 systems and components using expansion anchor bolts shall use the Drillco Maxi-Bolt Undercut Anchor System with the allowable anchor values listed in Appendix F

Anchorage capacity for new PC2/SDC2 and PC3/SDC3 systems and components using cast-in-place bolts (j-bolts, headed studs, etc.) and grouted-in-place bolts shall comply with ACI 349, *Code Requirements for Nuclear Safety Related Concrete Structures*. Anchorage capacity for new PC1/SDC1 systems and components shall comply with the IBC.

Anchorage for new and existing PC3/SDC3 systems and components using welded attachments shall use allowable weld stresses per ANSI/AISC N690, *Nuclear Facilities; Steel Safety Related Structures for Design, Fabrication, and Erection*.

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 7-16 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 4 by using the requirements for the source where interaction occurs.

Table 4 – Anchorage of Equipment

Performance Category/ Seismic Design Category	**PC3/SDC3**	**PC2/SDC2**	**PC1/SDC1**
Permanent Equipment	(1)	(1)	(1)
Temporary or Movable Equipment	(1)	(1)	(2)(3)

(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 7-16 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.*

(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 7-16 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 rattle space (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.*

(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.*

3.4 Requirements for Ecology Blocks

3.4.1 Existing Condition

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

3.4.2 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.

3.5 Design Loads

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

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

3.5.1 Dead Loads

Dead loads include the weights of all permanent materials and equipment, including the structure's 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 7-16. 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 the *American Association of State Highway and Transportation Officials (AASHTO)* standards. The unit weights for railway structures shall be those given in the *American Railway Engineering and Maintenance-of –Way Association (AREMA)* Manual for Railway Engineering.

3.5.2 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 7-16.
- 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.

3.5.3 Snow Loads

Snow loads, full or unbalanced, shall be substituted for roof live loads in Section 3.5.2 where such loading results in larger members or connections. Snow loads for buildings and other structures shall be in conformance with ASCE 7-16. 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.

3.5.4 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 SSCs on the Hanford Site (see HNF-SD-GN-ER-501, Rev. 3, *Natural Phenomena Hazards, Hanford Site, Washington*).

Wind design categorization (WDC) and wind load design for buildings and other structures shall comply with DOE-STD-1020-2016 and ASCE 7-16 and the wind parameters outlined in Table 5.

PC3/WDC3 SSCs shall be designed for wind-generated missiles. Wind-missile definitions for missile weight, maximum velocity, and maximum trajectory height are given in Table 5.

Table 5 – Wind Load and Missile Criteria

	PC3/WDC3	PC2/WDC2	PC1/WDC1
(ASCE 7-16) Ultimate Design Wind Speed (peak gust)	57 m/s (122 mph)	50 m/s (111 mph)	45 m/s (100 mph)
(ASCE 7-10) Ultimate Design Wind Speed (peak gust)	57 m/s (122 mph)	51 m/s (115 mph)	49 m/s (110 mph)
(ASCE 7-05) Nominal Design Wind Speed (peak gust)	45 m/s (95 mph)	41 m/s (91 mph)	38 m/s (85 mph)
Exposure Category	C	C	C
Missile (horizontal)	†	N/A	N/A
DOE-STD-1020-2016 Annual Exceedance Probability	$4x10^{-4}$	NA	N/A
ASCE-7-10 Annual Exceedance Probability	N/A	$5.88x10^{-4}$	$1.43x10^{-3}$

† 50 x 100 mm (2 x 4 in.) timber plank weighing 7 kg (15 lb) @ 22 m/s (50 mi/h). Maximum trajectory height = 9 m (30 ft).

NOTE: *Wind speed limit in ASCE 7-10 corresponds to the rounded value from the following relationship:* $V_{ASCE7\text{-}05\ (asd)} = V_{ASCE7\text{-}10\ (ult)} \sqrt{0.6}$ *(IBC 2015 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 7-16.

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.

3.5.5 Earthquake Loads

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

Earthquake load design of PC1/SDC1 SSCs shall comply with the IBC/ASCE 7, for standard occupancy facilities. Earthquake load design of PC2/SDC2 SSCs shall comply with the IBC/ASCE 7, for essential facilities. Seismic design parameters for PC1/SDC1 and PC2/SDC2 are given in Table 6, based on the Applied Technology Council (ATC) website: https://hazards.atcouncil.org for the Hanford Site

Table 6 – PC1/SDC1 and PC2/SDC2 Seismic Design Parameters

PC/SDC	PC1/SDC1	2/SDC2
Site Class*	D	D
S_s	0.399	0.399
S_1	0.157	0.157
F_a	1.481	1.481
F_v	2.286	2.286
S_{ms}	0.591	0.591
S_{m1}	0.359	0.359
Importance Factor (I_P)	1.0	1.5

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

b. PC3/SDC3 structures, systems, and components

Earthquake load design of PC3/SDC3 SSCs shall comply with DOE-STD-1020-2016 and ASCE 43-05 by using dynamic analysis and site-specific design response spectra outlined in Appendix D. An equivalent-static analysis may be used for seismic qualification as outlined in ASCE 43-05.

3.5.6 Ashfall Loads

Volcanic design categorization (VDC) and design consideration for volcanic hazards are defined in DOE-STD-1020-2016. New structural loads due to ash fallout are shown in Table 7 (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. 3)

Table 7 – 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
3	1×10^{-4}	112.29 (23)	1.5	1.1	2.650

(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 7-16 shall be used substituting the ashfall load, V, for the snow load, S, in the load combinations.

The design and evaluations of PC-3/VDC-3 shall be performed using ACI-349-13 and ANSI N690-12 provisions with the following load combinations, in additions to the basic combinations:

- D + 0.8L + (Lr or V)
- 0.9D + (Lr or V)
- Where, D is the dead load
- L is the live load
- Lr is the roof live load
- V is the ash load from volcanic eruptions

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 7) 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.

3.5.7 Flood Loads

Flood design for buildings and other structures and flood design categories (FDC) shall comply with DOE-STD-1020-2016.

3.5.7.1 Local Storm Runoff

Design-basis 6-hour precipitation levels are shown in Table 8.

Table 8 – Design-Basis Precipitation (PDC) Structural Loads Levels
(Source: Table 3, HNF-SD-GN-ER-501, Rev. 2)

PC/PDC	Probability	Return Period (yrs)	Amount (in.)
1	1×10^{-2}	100	1.8
2	5×10^{-3}	200	2.5
3	4×10^{-4}	2,500	4.0

3.5.7.2 Stream Flooding

Table 9 – Design-Basis Precipitation FLOODING (FDC)
(Source: Table 7-1 DOE-STD-1020-2016)

PC/FDC	Probability	Return Period (yrs)
1	2×10^{-3}	500
2	5×10^{-4}	2000
3	1×10^{-4}	10,000

The Columbia River flood stage elevation are obtained from Table 10.

Table 10 – 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 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)
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.

3.5.8 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 effect of dynamic earth pressures shall be considered in the design of PC3/SDC3 below grade structures. PC1/SDC1 and PC2/SDC2 below grade structures are not required to be evaluated for dynamic soil loads.

Soil properties for PC2/SDC2 and PC3/SDC3 structures shall be determined from subsurface investigations (see Section 2.8). A minimum soil density of 110 lbf/ft^3 should be used for PC1/SDC1 structures and may be used for PC2/SDC3, and PC3/SDC3 structures until the subsurface soil investigations are completed.

For PC1/SDC1 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/SDC1 and PC2/SDC2 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.

3.5.9 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.

3.5.9.1 Ambient Temperatures

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

3.5.9.2 Subsurface Temperature

For purposes other than frost and freeze protection, SSCs in all performance categories should be designed for subsurface temperature ranges as shown in Table 11.

Table 11 – Temperature Ranges for Subsurface SSC Operation
(Source: Table12 HNF-SD-GN-ER-501, Rev. 3)

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

3.5.10 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.

3.5.11 Lightning

Protection from lightning shall be considered for all SSCs. The PC/SDC, human occupancy, and economic value of the SSCs shall be considered when developing appropriate protection. NFPA 780, *Standard for the Installation of Lightning Protection Systems,* is the applicable NFPA standard for lighting protection.

3.5.12 Solar Radiation

All SSCs should be capable of operation in a solar radiation environment daily maximum of 900 langleys. (Source: HNF-SD-GN-ER-501, Rev. 3, Section 8.2)

3.5.13 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, ash load, and normal operating loads for all SSCs.

Load factors, load combinations, allowable stresses, and strength requirements for PC3/SDC 3 structures, systems, and components shall comply with ASCE 43-05 and DOE-STD-1020-2016.

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.

3.6 Design Acceptance Criteria

Guidance for selecting codes and standards that are necessary for the performance or maintenance of the safety function of SSCs as identified by the safety analysis and the safety equipment list (SEL) is in Appendix C.

3.7 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, “Safety Standards for Construction Work,” Part N.

The services of an engineer registered in the state of Washington specializing in underpinning shall be used to perform any underpinning design.

3.8 Subsurface Investigations

Subsurface investigations shall be made for 2/SDC2 and PC3/SDC3 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.

3.9 Design Criteria Implementation Process

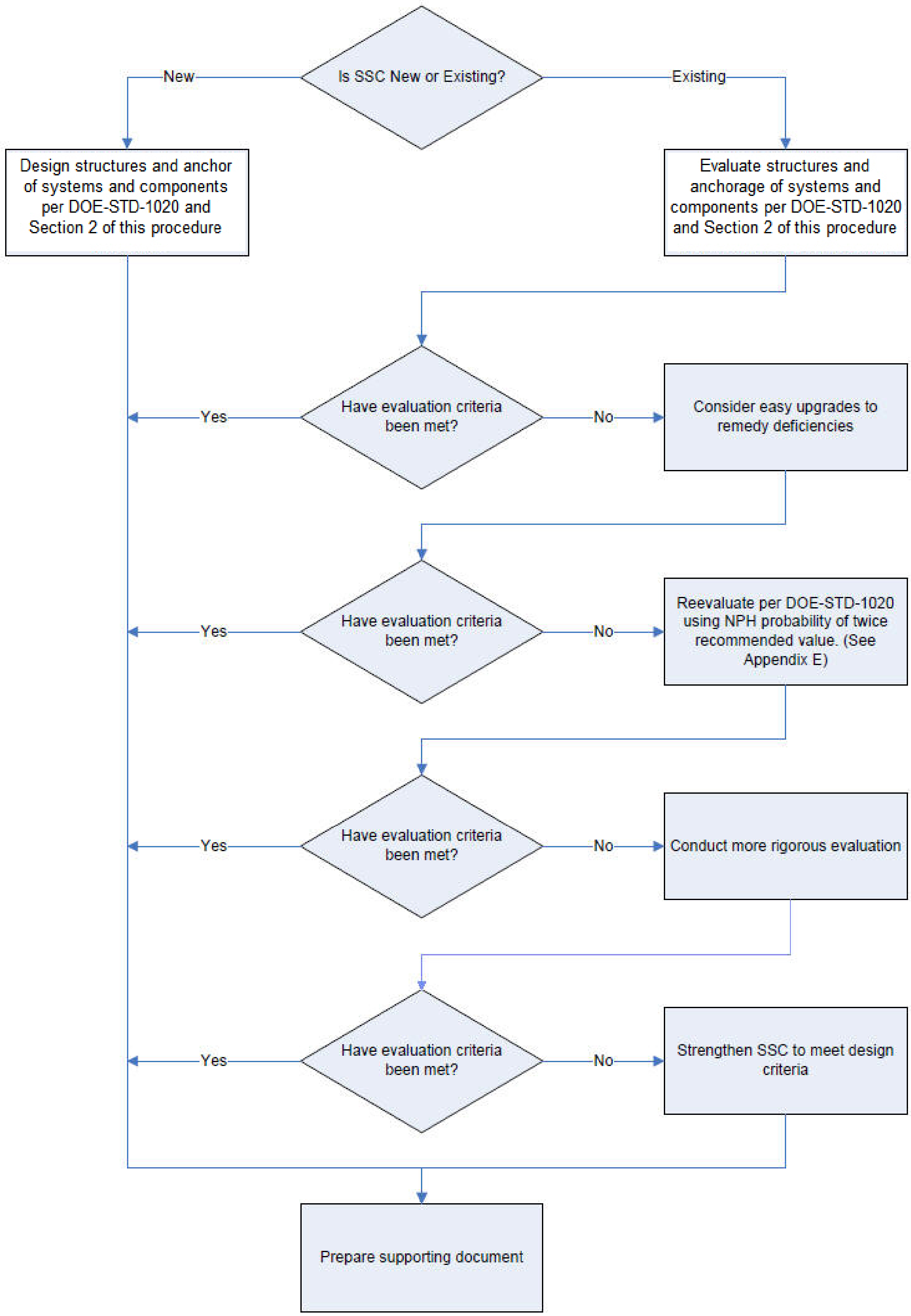
NOTE: *Figure 1 shows the process for determining design criteria. It should be used in conjunction with a SEL. Appendix C contains guidelines to select codes and standards that are applicable to the design and quality requirements for SSCs, based on their safety classification.*

Actionee	*Step*	*Action*
Design Engineer	1.	Using the SEL, OBTAIN information to identify the safety-related item, the safety and environmental protection function or attribute requiring structural qualification, and the safety designation of the item.
		a. IF the SEL has not yet been developed, THEN OBTAIN the safety function and safety designation of the item from the Design Authority for the project.
	2.	DETERMINE if SSC is new or existing.
	3.	IF it is new SSC, THEN DESIGN the structures and anchorage of systems per Section 3.0, AND GO TO Section 3.5.
	4.	IF it is an existing SSC, THEN EVALUATE the structures and anchorage of systems and components per Section 2.0.
		a. IF evaluation criteria have been met, THEN GO TO Section 3.5.
		b. IF evaluation criteria have not been met, THEN CONSIDER easy upgrades and reevaluate.
		c. IF evaluation criteria have been met, THEN GO TO Section 3.5.
		d. IF evaluation criteria have not been met, THEN reevaluate per DOE-STD-1020-2016 using NPH probability of twice the recommended value (see Appendix E).
		e. IF evaluation criteria have been met, THEN GO TO Section 3.5.
		f. IF evaluation criteria have not been met, THEN CONDUCT a more rigorous evaluation.
		g. IF evaluation criteria have been met, THEN GO TO Section 3.5.

Actionee	*Step*	*Action*
Design Engineer		h. IF evaluation criteria have not been met, THEN STRENGTHEN SSC to meet design criteria.

5. PREPARE a Supporting Document.

Figure 1 – Design Criteria Implementation



4.0 FORMS

None

5.0 RECORD IDENTIFICATION

All records are required to be managed in accordance with CPCC-PRO-IRM-10588, *Records Management Processes*.

Records Capture Table

Name of Record	Submittal Responsibility	Retention Responsibility
Supporting Document	Design Engineer	IRM Services Provider

6.0 SOURCES

6.1 Requirements

ASCE 7-16, Minimum Design Loads for Buildings and Other Structures
DOE-STD-1020-2016, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,
IBC 2018*, International Building Code*
CPCC-MP-PMT-54915*, Real Property Asset Program Plan*

6.2 References

NOTE: *Use current revision except where date is specified.*

AASHTO*, American Association of State Highway and Transportation Officials*
ACI 301, *Specifications for Structural Concrete*
ACI 318, *Building Code Requirements for Structural Concrete*
ACI 349, *Code Requirements for Nuclear Safety Related Concrete Structures*
AISC 325-05, Steel Construction Manual
ANSI/AISC N690, *Nuclear Facilities; Steel Safety Related Structures for Design, Fabrication, and Erection*
ANSI/ANS 2.26-2004, *Categorization of Nuclear Facility Structures, Systems and Components for Seismic Design*
AREMA, *American Railway Engineering and Maintenance-of –Way Association*
ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*
ASCE/SEI 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*
ASTM A193, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*
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 A706, *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement*

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

DOE G 420.1-1, *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide*

DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C,* DOE O 420.1C, *Facility Safety*

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*

HNF-SD-GN-ER-501 Rev. 3, *Natural Phenomena Hazards, Hanford Site, Washington*.

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

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

Term	Definition
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).
Major modification	As defined in DOE STD 1189, *Integration of Safety into the Design Process* (Modifications that substantially change the existing safety basis for the facility).
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.

Appendix A - Glossary

Term	Definition
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).

Appendix B - 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
API	American Petroleum Institute
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
ATC	Applied Technology Council
AWS	American Welding Society
AWWA	American Water Works Association
DOE	U.S. Department of Energy
DOE-STD	U.S. Department of Energy, Standard
CMAA	Crane Manufacturer Association of America
EBF	eccentric braced frame
EIA	Electronics Industries Association
FDC	Flood Design Category
ft	foot
h	hour
HC	hazard category
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC-ES	International Code Council Evaluation Service
IMRF	intermediate moment resisting frame
in.	inch
ISP	institutional safety program
kg	kilogram
km	kilometer
lb	pound-mass
lbf	pound-force
m	meter
MBMA	Metal Building Manufacturers Association
mi	mile
mm	millimeter
NDC	NPH Design Category
NFPA	National Fire Protection Association
NPH	natural phenomena hazard
NTIA	National Telecommunications and Information Administration
OSHA	Occupational Safety and Health Administration
Pa	Pascal
PDC	Precipitation Design Category
PHMS	Project Hanford Management System
PSO	Program Secretarial Officer
s	second
SAR	safety analysis report

Appendix B - (Cont.) Acronyms and Abbreviations

SC	safety class
SDC	Seismic Design Category
SDI	Steel Deck Institute
SEL	safety equipment list
SF	scale factor
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Manufacturers National Association
SMRF	special moment resisting frame
SRSS	square-root-of-the-sum-of-the-squares
SSC	structure, system, and component
SSFI	Scaffolding, Shoring, and Framing Institute
TEMA	Tubular Exchanger Manufacturers Association
TM	Technical Manual, National Technical Information Service
UBC	Uniform Building Code UL Underwriters' Laboratories
UPC	Uniform Plumbing Code
UCRL	University of California Radiation Laboratory
VDC	Volcanic Design Category
WAC	Washington Administrative Code
WDC	Wind Design Category
WHC	Westinghouse Hanford Company

Appendix C - Guidance for Selecting National Codes and Standards

The most common national consensus codes and standards applicable to the design and quality requirements for structures, systems, and components (SSCs), based on their safety classification, are listed in Table C-1.

When applying design criteria to an SSC, 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 C-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 the SEL. These codes and standards should be considered for guidance where codes and standards are not specified in Section 2.0 of this document, other codes and standards may also apply. Codes and standards identified under "Safety Class" were developed specifically for nuclear reactors, and their use requires judgment for nonreactor applications.

Appendix C - (Cont.) Guidance for Selecting National Codes and Standards

Table C-1 – Guidance For Use of National Codes and Standards
(2 sheets total)

Design Category	(PC1/NDC1)	(PC2/NDC2)	(PC3/NDC3)
Structural – Steel	IBC; AISC	Same as PC1	ANSI-N690
Steel Cables for Buildings	ASCE 19	Same as PC1	Same as PC1
Steel Decks	SDI Publ. 29; SDI Publ. DDM02	Same as PC1	Same as PC1
Steel Joists	SJI	Same as PC1	Same as PC1
Welding	AWS D1.1; AWS D1.2; AWS D1.3; AWS D1.6	Same as PC1	Same as PC1
Light-gauge Steel	AISI	Same as PC1	Same as PC1
Pre-Engineered Metal Buildings	MBMA	Same as PC1	Same as PC1
Structural Concrete	IBC; ACI-318;	Same as PC1	ACI-349
Sanitary Engineering Concrete Structures	ACI 350R	Same as PC1	Same as PC1
Structural – Masonry	IBC; ACI 530; ACI 530.1	Same as PC1	Same as PC1
Structural – Wood	IBC	Same as PC1	Same as PC1
Access Flooring	IBC	Same as PC1	Same as PC1
Ceiling Suspension Systems	IBC; ASTM C 635; ASTM C 636; ASTM E580; ICBO ER-4071	Same as PC1	Same as PC1
Highway Structures	AASHTO HB-16	Same as PC1	Same as PC1
Railway Structures	AREMA Manual	Same as PC1	Same as PC1
Towers and poles	ASCE 52; NTIA Manual Chapter 5; ASCE 72	Same as PC1	Same as PC1
Chimneys and Stacks	ACI 307; ASME STS-1; IBC	Same as PC1	Same as PC1
Ducts	SMACNA Manual	Same as PC1	Same as PC1
Fans	ASHRAE Handbook	Same as PC1	ASME AG-1
Filtration	ASHRAE Handbook	ASHRAE-52.1; Mil-F-51068F; ASME-N509 and N510; DOE NE STD-F3-45	ASHRAE-52.1; Mil-F-51068F; ASME-N509 and N510; DOE-STD-3020-97 ASME AG-1
Pressure Vessels	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2	Same as PC1	Same as PC1
Tanks (0 – 15 psig)	API-620;ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2	Same as PC1	Same as PC1
Tanks (containing flammable liquids)	API-620; API-650; NFPA 30	Same as PC1	Same as PC1

Appendix C - (Cont.) Guidance for Selecting National Codes and Standards

Table C-1 – Guidance For Use of National Codes and Standards
(2 sheets total)

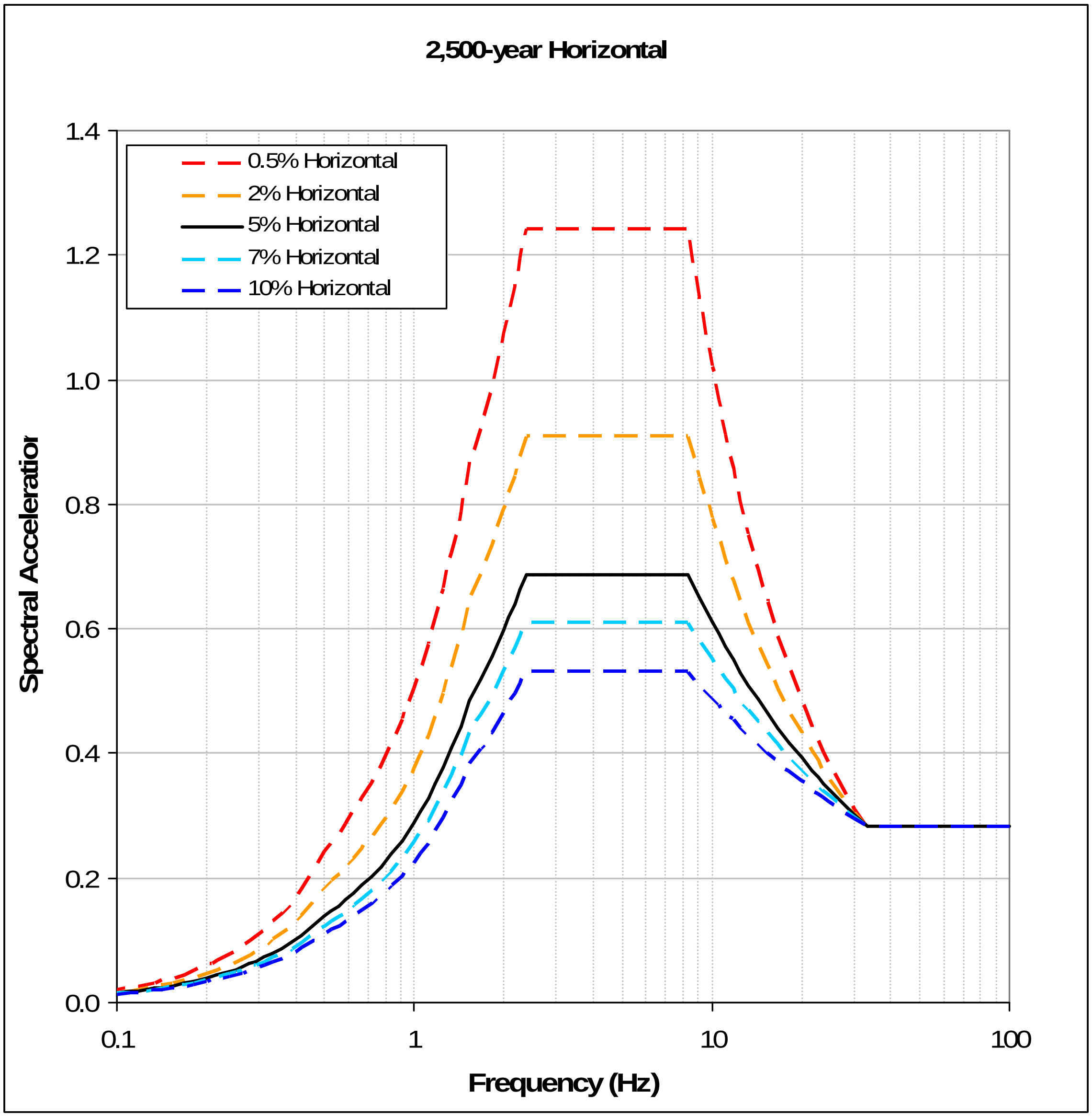
Design Category	(PC1/NDC1)	(PC2/NDC2)	(PC3/NDC3)
Tanks (atmospheric pressure)	API-650; AWWA-D100; ASME-B96.1	Same as PC1	Same as PC1
Pumps	API; ASME B73.1M, B73.2M; AWWA; Hydraulic Institute Standards; ASME Boiler and Pressure Vessel Code, Section VIII	Same as PC1	Same as PC1
Piping	UPC; ASME B16.xx, B31.1, B31.3, B31.9; AWWA	Same as PC1	ASME B31.3; ANSI-N278.1
Valves	ASME B16.5, ASME B31.3	Same as PC1	Same as PC1
Heat Exchangers	ASHRAE Handbook; ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; TEMA B, C, or R	Same as PC1	Same as PC1
Gloveboxes	ASTM C852; ANS 11.16	Same as PC1	Same as PC1
Cranes	CMAA DOE-RL-92-36	CMAA; ASME NOG-1; ASME NUM-1; ASME B30.2; DOE-STD-1090-96 DOE-RL-92-36	CMAA Nuclear Sections; ASME NOG-1; ASME NUM-1; ASME B30.2; DOE-STD-1090-96 DOE-RL-92-36
Other equipment	ANSI N14.6; AISC-ASD or AISC-LRFD	Same as PC1	Same as PC1
Fire Protection	NFPA	Same as PC1	Same as PC1
Lightning	NFPA 780	NFPA 780	NFPA 780
Electrical	Applicable NFPA Codes and Standards	Applicable NFPA Codes and Standards	Applicable NFPA Codes and Standards

* ASME III or other comparable safety-related codes and standards appropriate for the system being designed.

For reference document titles see Section 6.0.
For acronyms and abbreviations see Appendix B.

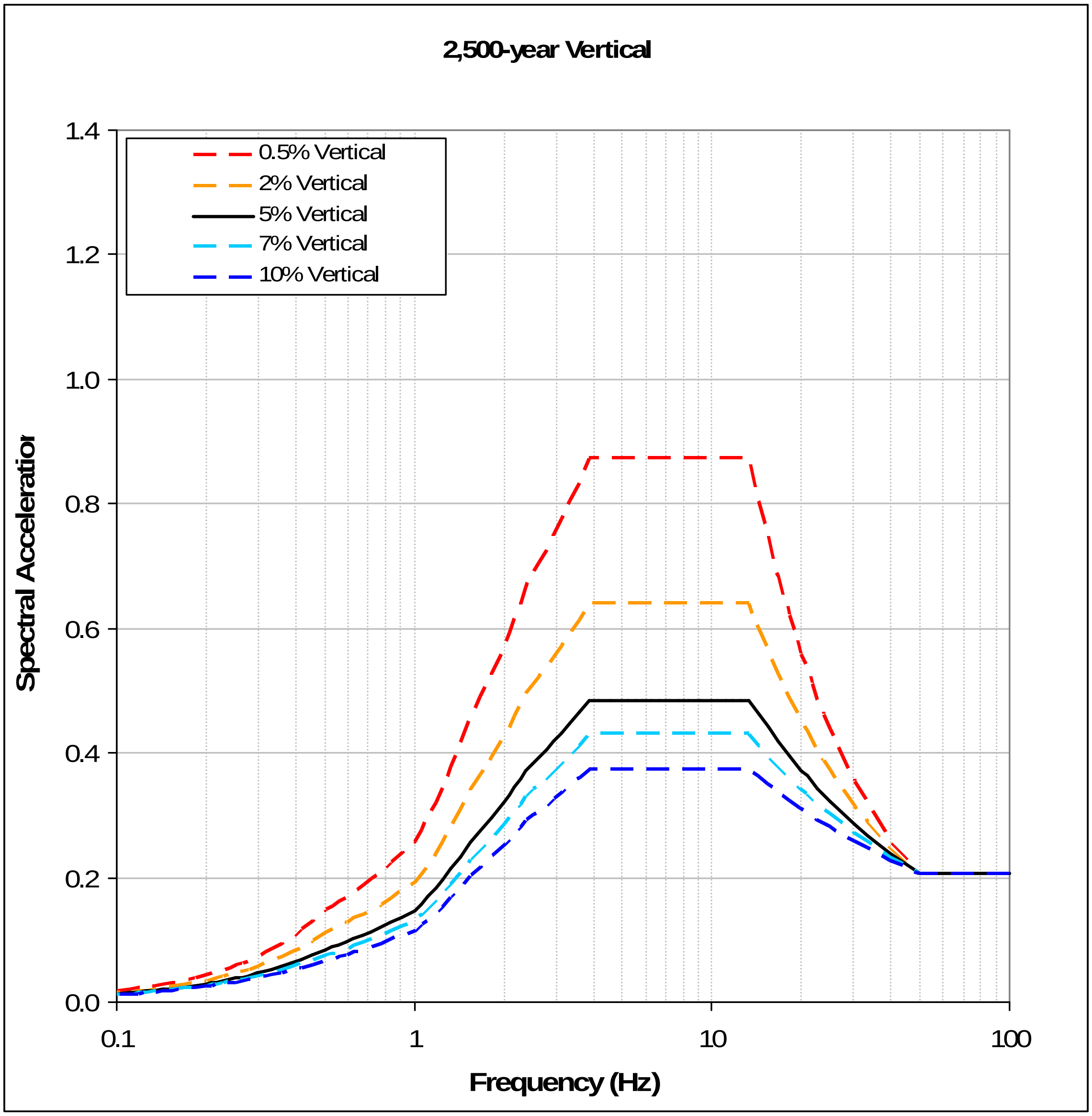
Appendix D - Interim Site-Specific Design Response Spectra

Figure D-1. Interim 2,500-year Horizontal Response Spectra



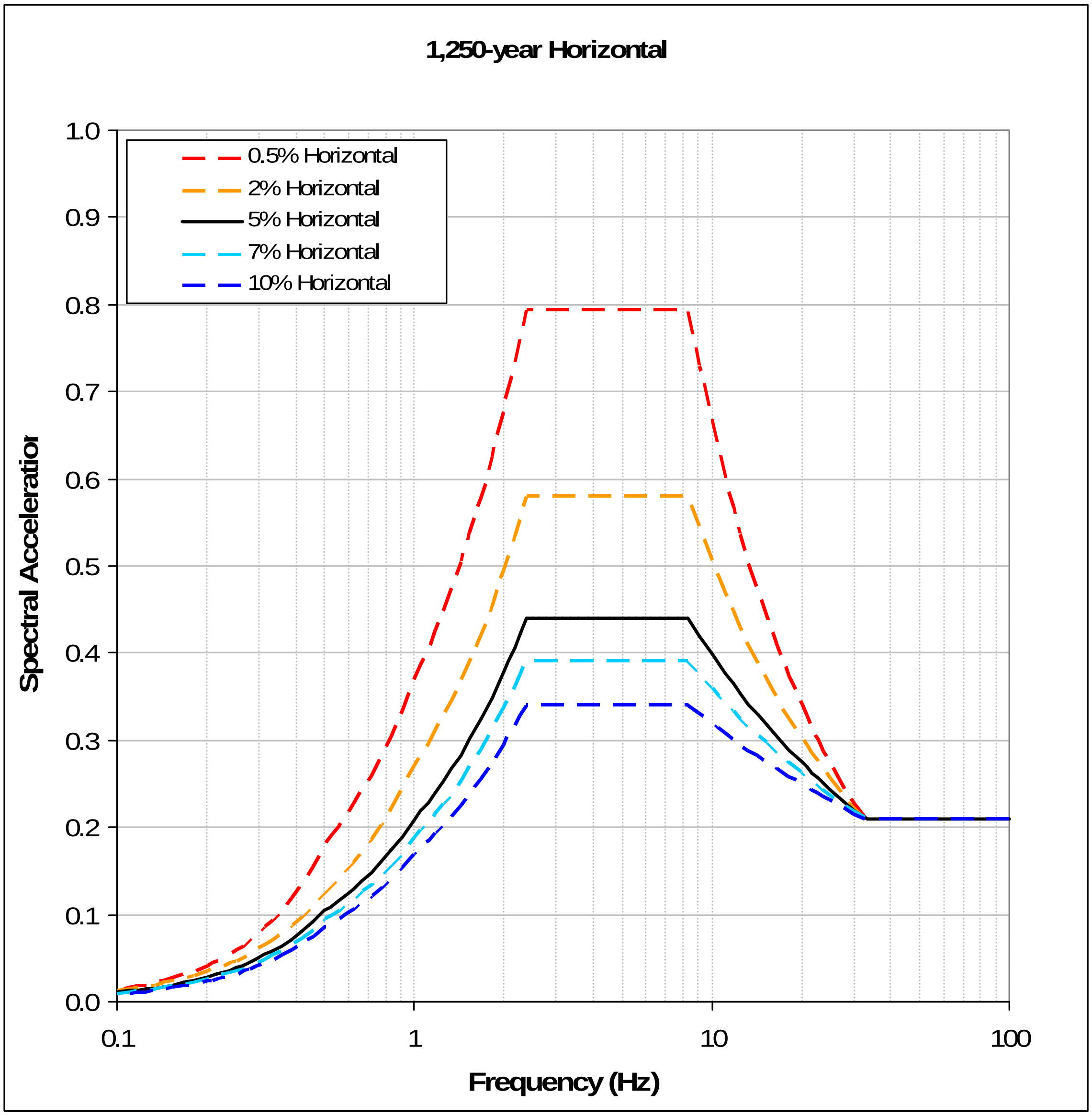
Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Figure D-2. Interim 2,500-year Vertical Response Spectra



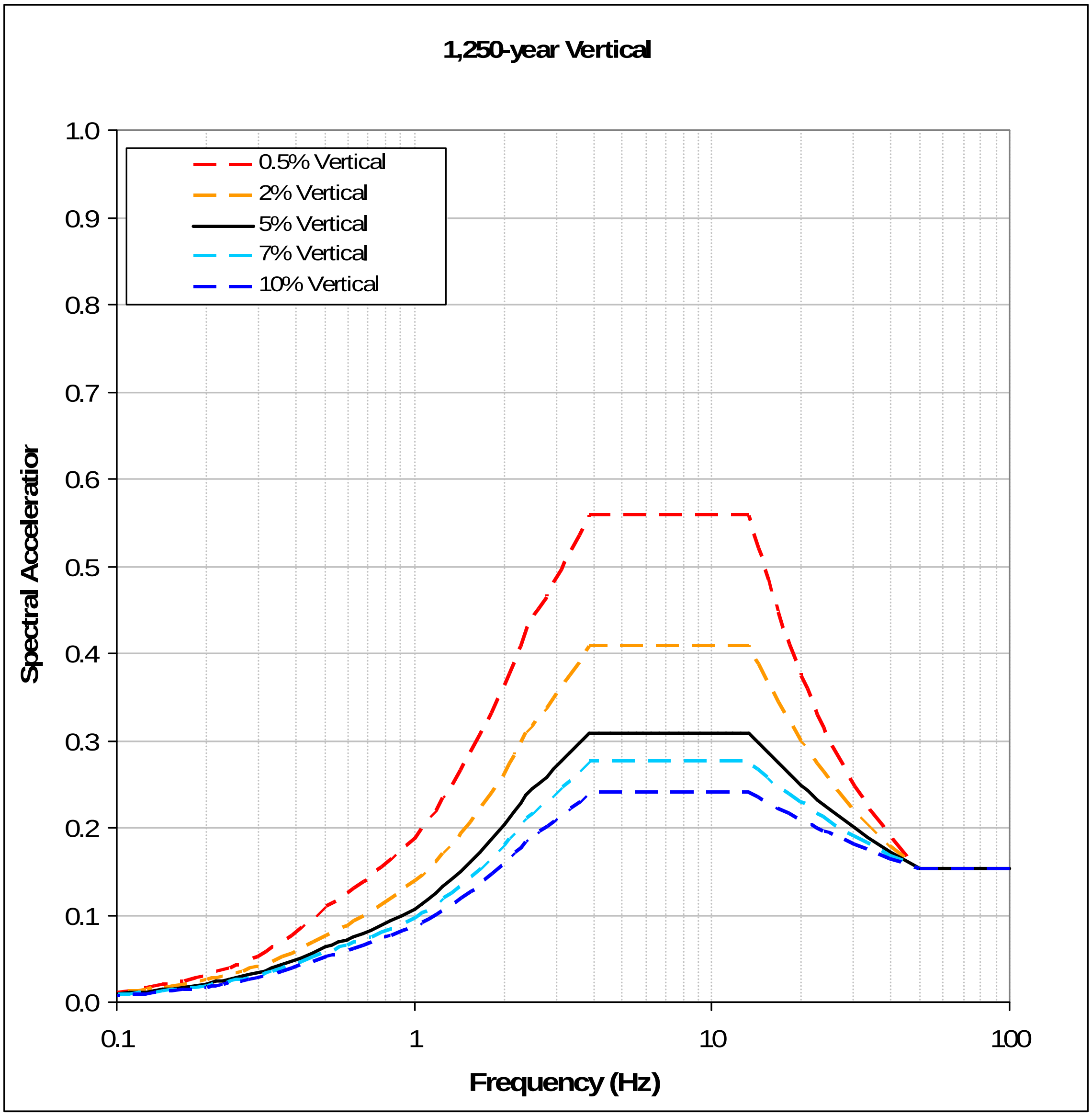
Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Figure D-3. Interim 1,250-year Horizontal Response Spectra



Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Figure D-4. Interim 1,250-year Vertical Response Spectra



Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-5 – Interim 2,500-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
100	0.2826	0.2826	0.2826	0.2826	0.2826	0.2060	0.2060	0.2060	0.2060	0.2060
58.824	0.2826	0.2826	0.2826	0.2826	0.2826	0.2060	0.2060	0.2060	0.2060	0.2060
50	0.2826	0.2826	0.2826	0.2826	0.2826	0.2060	0.2060	0.2060	0.2060	0.2060
40	0.2826	0.2826	0.2826	0.2826	0.2826	0.2629	0.2494	0.2379	0.2333	0.2279
33.333	0.2826	0.2826	0.2826	0.2826	0.2826	0.3208	0.2916	0.2677	0.2583	0.2475
30.303	0.3129	0.3062	0.3004	0.2980	0.2952	0.3561	0.3164	0.2847	0.2724	0.2584
25	0.3842	0.3602	0.3399	0.3318	0.3223	0.4394	0.3732	0.3224	0.3033	0.2819
23.81	0.4047	0.3753	0.3507	0.3409	0.3296	0.4635	0.3892	0.3327	0.3116	0.2882
22.727	0.4254	0.3903	0.3613	0.3499	0.3367	0.4877	0.4050	0.3428	0.3198	0.2943
21.739	0.4460	0.4052	0.3718	0.3586	0.3436	0.5120	0.4207	0.3528	0.3279	0.3003
20.833	0.4668	0.4200	0.3820	0.3673	0.3503	0.5364	0.4364	0.3627	0.3358	0.3062
20	0.4876	0.4347	0.3922	0.3757	0.3569	0.5608	0.4519	0.3724	0.3435	0.3119
18.182	0.5398	0.4711	0.4169	0.3962	0.3728	0.6224	0.4904	0.3960	0.3623	0.3256
16.667	0.5923	0.5069	0.4408	0.4159	0.3879	0.6845	0.5284	0.4189	0.3803	0.3387
15.385	0.6452	0.5423	0.4641	0.4349	0.4024	0.7471	0.5660	0.4412	0.3977	0.3512
14.286	0.6983	0.5772	0.4867	0.4532	0.4163	0.8102	0.6031	0.4628	0.4145	0.3632
13.333	0.7517	0.6118	0.5087	0.4710	0.4296	0.8737	0.6399	0.4839	0.4308	0.3748
12.5	0.8053	0.6460	0.5302	0.4883	0.4425	0.8737	0.6399	0.4839	0.4308	0.3748
11.765	0.8591	0.6799	0.5512	0.5050	0.4549	0.8737	0.6399	0.4839	0.4308	0.3748
11.111	0.9132	0.7135	0.5718	0.5214	0.4669	0.8737	0.6399	0.4839	0.4308	0.3748
10.526	0.9675	0.7468	0.5920	0.5374	0.4786	0.8737	0.6399	0.4839	0.4308	0.3748
10	1.0219	0.7797	0.6118	0.5530	0.4900	0.8737	0.6399	0.4839	0.4308	0.3748
9.091	1.1314	0.8450	0.6504	0.5831	0.5118	0.8737	0.6399	0.4839	0.4308	0.3748
8.333	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
7.692	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
7.143	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
6.667	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
6.25	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
5.882	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
5.556	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
5.263	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
5	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
4.545	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
4.167	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
3.846	1.2416	0.9093	0.6877	0.6121	0.5326	0.8737	0.6399	0.4839	0.4308	0.3748
3.571	1.2416	0.9093	0.6877	0.6121	0.5326	0.8381	0.6153	0.4647	0.4139	0.3608
3.333	1.2416	0.9093	0.6877	0.6121	0.5326	0.8063	0.5934	0.4474	0.3988	0.3483
3.125	1.2416	0.9093	0.6877	0.6121	0.5326	0.7776	0.5735	0.4319	0.3852	0.3370

Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-5 – Interim 2,500-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
2.941	1.2416	0.9093	0.6877	0.6121	0.5326	0.7516	0.5555	0.4178	0.3728	0.3267
2.778	1.2416	0.9093	0.6877	0.6121	0.5326	0.7279	0.5390	0.4050	0.3615	0.3173
2.632	1.2416	0.9093	0.6877	0.6121	0.5326	0.7062	0.5239	0.3932	0.3511	0.3087
2.5	1.2416	0.9093	0.6877	0.6121	0.5326	0.6861	0.5099	0.3822	0.3415	0.3007
2.381	1.2416	0.9093	0.6877	0.6121	0.5326	0.6676	0.4969	0.3722	0.3327	0.2932
2.273	1.1947	0.8770	0.6628	0.5904	0.5145	0.6414	0.4777	0.3579	0.3200	0.2822
2.174	1.1514	0.8470	0.6397	0.5704	0.4978	0.6172	0.4599	0.3447	0.3084	0.2719
2.083	1.1112	0.8192	0.6184	0.5517	0.4822	0.5949	0.4435	0.3325	0.2975	0.2624
2	1.0744	0.7936	0.5987	0.5346	0.4678	0.5743	0.4284	0.3213	0.2876	0.2537
1.818	0.9926	0.7366	0.5550	0.4964	0.4358	0.5290	0.3950	0.2965	0.2656	0.2344
1.667	0.9237	0.6884	0.5180	0.4640	0.4086	0.4908	0.3669	0.2756	0.2470	0.2181
1.538	0.8640	0.6465	0.4859	0.4359	0.3849	0.4579	0.3426	0.2575	0.2310	0.2039
1.429	0.7884	0.5894	0.4442	0.3988	0.3516	0.4155	0.3106	0.2341	0.2102	0.1853
1.333	0.7229	0.5401	0.4081	0.3667	0.3228	0.3790	0.2832	0.2140	0.1923	0.1693
1.25	0.6672	0.4981	0.3774	0.3393	0.2983	0.3481	0.2599	0.1969	0.1771	0.1556
1.176	0.6183	0.4613	0.3503	0.3152	0.2767	0.3212	0.2397	0.1820	0.1637	0.1437
1.111	0.5760	0.4295	0.3269	0.2943	0.2580	0.2979	0.2222	0.1691	0.1522	0.1335
1.053	0.5387	0.4015	0.3062	0.2758	0.2416	0.2776	0.2069	0.1578	0.1421	0.1245
1	0.5051	0.3763	0.2876	0.2591	0.2267	0.2592	0.1931	0.1476	0.1330	0.1164
0.909	0.4570	0.3418	0.2602	0.2342	0.2056	0.2401	0.1795	0.1367	0.1230	0.1080
0.833	0.4171	0.3129	0.2374	0.2135	0.1880	0.2238	0.1679	0.1274	0.1145	0.1009
0.769	0.3836	0.2887	0.2183	0.1961	0.1732	0.2099	0.1580	0.1194	0.1073	0.0948
0.714	0.3549	0.2679	0.2019	0.1812	0.1605	0.1977	0.1493	0.1125	0.1010	0.0894
0.667	0.3305	0.2501	0.1880	0.1686	0.1496	0.1872	0.1417	0.1065	0.0955	0.0848
0.625	0.3087	0.2342	0.1756	0.1574	0.1400	0.1777	0.1348	0.1011	0.0906	0.0806
0.588	0.2896	0.2202	0.1647	0.1475	0.1315	0.1692	0.1287	0.0962	0.0862	0.0768
0.556	0.2731	0.2081	0.1553	0.1390	0.1241	0.1617	0.1233	0.0921	0.0823	0.0735
0.526	0.2577	0.1968	0.1466	0.1311	0.1173	0.1547	0.1181	0.0880	0.0787	0.0704
0.5	0.2443	0.1870	0.1390	0.1242	0.1113	0.1485	0.1136	0.0845	0.0755	0.0677
0.455	0.2113	0.1621	0.1220	0.1095	0.0984	0.1312	0.1007	0.0758	0.0680	0.0611
0.417	0.1848	0.1421	0.1082	0.0975	0.0879	0.1171	0.0900	0.0686	0.0618	0.0557
0.385	0.1634	0.1259	0.0969	0.0877	0.0792	0.1054	0.0813	0.0626	0.0566	0.0511
0.357	0.1455	0.1123	0.0874	0.0793	0.0717	0.0955	0.0737	0.0574	0.0520	0.0471
0.333	0.1307	0.1011	0.0794	0.0723	0.0655	0.0872	0.0674	0.0529	0.0482	0.0437
0.313	0.1188	0.0921	0.0729	0.0665	0.0604	0.0804	0.0623	0.0494	0.0450	0.0409
0.294	0.1079	0.0838	0.0668	0.0612	0.0557	0.0740	0.0575	0.0459	0.0420	0.0382
0.278	0.0990	0.0770	0.0619	0.0568	0.0518	0.0688	0.0535	0.0430	0.0395	0.0360
0.263	0.0909	0.0708	0.0573	0.0528	0.0482	0.0640	0.0498	0.0404	0.0371	0.0339

Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-5 – Interim 2,500-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
0.25	0.0841	0.0655	0.0535	0.0493	0.0451	0.0599	0.0467	0.0381	0.0351	0.0321
0.238	0.0779	0.0608	0.0500	0.0462	0.0423	0.0561	0.0438	0.0360	0.0333	0.0304
0.227	0.0725	0.0566	0.0468	0.0434	0.0397	0.0528	0.0412	0.0341	0.0316	0.0289
0.217	0.0676	0.0529	0.0440	0.0408	0.0375	0.0497	0.0389	0.0324	0.0300	0.0276
0.208	0.0633	0.0496	0.0415	0.0386	0.0355	0.0470	0.0369	0.0308	0.0287	0.0263
0.2	0.0596	0.0468	0.0393	0.0366	0.0337	0.0447	0.0351	0.0295	0.0275	0.0252
0.182	0.0516	0.0405	0.0345	0.0323	0.0298	0.0395	0.0311	0.0265	0.0247	0.0228
0.167	0.0452	0.0356	0.0307	0.0288	0.0266	0.0353	0.0278	0.0240	0.0225	0.0208
0.154	0.0399	0.0315	0.0274	0.0259	0.0240	0.0317	0.0251	0.0218	0.0206	0.0191
0.143	0.0356	0.0282	0.0248	0.0234	0.0217	0.0288	0.0228	0.0200	0.0190	0.0176
0.133	0.0318	0.0252	0.0224	0.0213	0.0198	0.0262	0.0208	0.0185	0.0175	0.0163
0.125	0.0289	0.0230	0.0206	0.0196	0.0182	0.0241	0.0192	0.0172	0.0163	0.0152
0.118	0.0265	0.0211	0.0190	0.0181	0.0169	0.0224	0.0178	0.0160	0.0153	0.0143
0.111	0.0241	0.0192	0.0175	0.0167	0.0156	0.0207	0.0165	0.0150	0.0143	0.0134
0.1	0.0205	0.0164	0.0151	0.0145	0.0136	0.0180	0.0144	0.0133	0.0128	0.0120

Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-6 – Interim 1,250-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
100	0.2091	0.2091	0.2091	0.2091	0.2091	0.1524	0.1524	0.1524	0.1524	0.1524
58.824	0.2091	0.2091	0.2091	0.2091	0.2091	0.1524	0.1524	0.1524	0.1524	0.1524
50	0.2091	0.2091	0.2091	0.2091	0.2091	0.1524	0.1524	0.1524	0.1524	0.1524
40	0.2091	0.2091	0.2091	0.2091	0.2091	0.1897	0.1800	0.1717	0.1684	0.1645
33.333	0.2091	0.2091	0.2091	0.2091	0.2091	0.2270	0.2062	0.1893	0.1828	0.1752
30.303	0.2291	0.2243	0.2200	0.2183	0.2162	0.2493	0.2214	0.1992	0.1908	0.1811
25	0.2758	0.2584	0.2439	0.2382	0.2315	0.3012	0.2555	0.2208	0.2080	0.1935
23.81	0.2890	0.2679	0.2503	0.2435	0.2355	0.3160	0.2650	0.2266	0.2126	0.1968
22.727	0.3023	0.2772	0.2567	0.2487	0.2394	0.3308	0.2744	0.2324	0.2171	0.1999
21.739	0.3155	0.2864	0.2628	0.2538	0.2432	0.3456	0.2836	0.2380	0.2215	0.2030
20.833	0.3287	0.2955	0.2689	0.2587	0.2469	0.3604	0.2928	0.2434	0.2257	0.2060
20	0.3419	0.3046	0.2748	0.2635	0.2505	0.3751	0.3018	0.2488	0.2299	0.2089
18.182	0.3747	0.3267	0.2892	0.2752	0.2591	0.4120	0.3241	0.2618	0.2400	0.2159
16.667	0.4075	0.3483	0.3030	0.2863	0.2672	0.4488	0.3458	0.2743	0.2495	0.2225
15.385	0.4401	0.3695	0.3163	0.2968	0.2749	0.4855	0.3671	0.2863	0.2587	0.2287
14.286	0.4727	0.3902	0.3291	0.3070	0.2822	0.5222	0.3880	0.2979	0.2674	0.2346
13.333	0.5051	0.4106	0.3415	0.3167	0.2891	0.5589	0.4085	0.3092	0.2758	0.2403
12.5	0.5375	0.4306	0.3535	0.3261	0.2958	0.5589	0.4085	0.3092	0.2758	0.2403
11.765	0.5698	0.4502	0.3652	0.3352	0.3022	0.5589	0.4085	0.3092	0.2758	0.2403
11.111	0.6021	0.4696	0.3766	0.3440	0.3084	0.5589	0.4085	0.3092	0.2758	0.2403
10.526	0.6343	0.4887	0.3876	0.3526	0.3144	0.5589	0.4085	0.3092	0.2758	0.2403
10	0.6664	0.5075	0.3984	0.3609	0.3201	0.5589	0.4085	0.3092	0.2758	0.2403
9.091	0.7304	0.5444	0.4193	0.3768	0.3311	0.5589	0.4085	0.3092	0.2758	0.2403
8.333	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
7.692	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
7.143	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
6.667	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
6.25	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
5.882	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
5.556	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
5.263	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
5	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
4.545	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
4.167	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
3.846	0.7943	0.5805	0.4393	0.3920	0.3415	0.5589	0.4085	0.3092	0.2758	0.2403
3.571	0.7943	0.5805	0.4393	0.3920	0.3415	0.5361	0.3914	0.2968	0.2648	0.2308
3.333	0.7943	0.5805	0.4393	0.3920	0.3415	0.5157	0.3761	0.2858	0.2549	0.2224
3.125	0.7943	0.5805	0.4393	0.3920	0.3415	0.4974	0.3624	0.2759	0.2460	0.2147

Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-6 – Interim 1,250-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
2.941	0.7943	0.5805	0.4393	0.3920	0.3415	0.4808	0.3499	0.2669	0.2378	0.2078
2.778	0.7943	0.5805	0.4393	0.3920	0.3415	0.4656	0.3386	0.2587	0.2305	0.2015
2.632	0.7943	0.5805	0.4393	0.3920	0.3415	0.4517	0.3282	0.2512	0.2237	0.1956
2.5	0.7943	0.5805	0.4393	0.3920	0.3415	0.4388	0.3186	0.2442	0.2174	0.1903
2.381	0.7943	0.5805	0.4393	0.3920	0.3415	0.4270	0.3097	0.2378	0.2117	0.1853
2.273	0.7623	0.5568	0.4222	0.3769	0.3289	0.4092	0.2969	0.2280	0.2031	0.1780
2.174	0.7328	0.5350	0.4064	0.3630	0.3172	0.3927	0.2850	0.2190	0.1952	0.1713
2.083	0.7055	0.5148	0.3917	0.3501	0.3064	0.3776	0.2741	0.2106	0.1879	0.1651
2	0.6806	0.4963	0.3783	0.3382	0.2965	0.3638	0.2641	0.2030	0.1813	0.1594
1.818	0.6254	0.4556	0.3486	0.3120	0.2744	0.3332	0.2421	0.1862	0.1665	0.1467
1.667	0.5791	0.4215	0.3236	0.2900	0.2558	0.3077	0.2236	0.1722	0.1542	0.1361
1.538	0.5393	0.3920	0.3020	0.2709	0.2396	0.2858	0.2077	0.1600	0.1435	0.1270
1.429	0.5056	0.3683	0.2836	0.2548	0.2261	0.2665	0.1941	0.1495	0.1343	0.1192
1.333	0.4757	0.3472	0.2672	0.2405	0.2141	0.2494	0.1820	0.1401	0.1261	0.1122
1.25	0.4496	0.3287	0.2528	0.2280	0.2035	0.2346	0.1715	0.1319	0.1190	0.1062
1.176	0.4261	0.3121	0.2399	0.2167	0.1939	0.2214	0.1621	0.1246	0.1126	0.1007
1.111	0.4054	0.2974	0.2285	0.2067	0.1854	0.2097	0.1538	0.1182	0.1069	0.0959
1.053	0.3868	0.2841	0.2183	0.1977	0.1778	0.1993	0.1464	0.1124	0.1019	0.0916
1	0.3696	0.2719	0.2088	0.1894	0.1707	0.1897	0.1396	0.1072	0.0972	0.0876
0.909	0.3350	0.2446	0.1897	0.1723	0.1554	0.1760	0.1285	0.0996	0.0905	0.0816
0.833	0.3061	0.2221	0.1737	0.1580	0.1426	0.1643	0.1192	0.0932	0.0848	0.0765
0.769	0.2819	0.2033	0.1603	0.1460	0.1318	0.1542	0.1112	0.0877	0.0799	0.0721
0.714	0.2611	0.1872	0.1488	0.1356	0.1225	0.1455	0.1043	0.0829	0.0756	0.0683
0.667	0.2434	0.1736	0.1389	0.1267	0.1146	0.1379	0.0984	0.0787	0.0718	0.0649
0.625	0.2276	0.1616	0.1301	0.1188	0.1075	0.1310	0.0930	0.0749	0.0684	0.0619
0.588	0.2137	0.1510	0.1224	0.1118	0.1012	0.1248	0.0882	0.0715	0.0653	0.0591
0.556	0.2017	0.1419	0.1157	0.1058	0.0958	0.1195	0.0841	0.0686	0.0626	0.0567
0.526	0.1905	0.1335	0.1094	0.1001	0.0907	0.1144	0.0801	0.0657	0.0601	0.0545
0.5	0.1808	0.1262	0.1040	0.0952	0.0863	0.1099	0.0767	0.0632	0.0579	0.0524
0.455	0.1554	0.1105	0.0909	0.0833	0.0755	0.0965	0.0686	0.0565	0.0517	0.0469
0.417	0.1352	0.0977	0.0803	0.0736	0.0667	0.0856	0.0619	0.0509	0.0466	0.0423
0.385	0.1189	0.0873	0.0717	0.0657	0.0596	0.0767	0.0563	0.0463	0.0424	0.0385
0.357	0.1054	0.0785	0.0644	0.0590	0.0536	0.0692	0.0515	0.0423	0.0387	0.0352
0.333	0.0943	0.0711	0.0583	0.0535	0.0485	0.0629	0.0474	0.0389	0.0357	0.0324
0.313	0.0854	0.0652	0.0534	0.0490	0.0444	0.0578	0.0441	0.0362	0.0331	0.0301
0.294	0.0772	0.0597	0.0488	0.0448	0.0407	0.0530	0.0410	0.0335	0.0308	0.0279
0.278	0.0706	0.0551	0.0451	0.0414	0.0376	0.0491	0.0383	0.0313	0.0288	0.0261
0.263	0.0646	0.0510	0.0417	0.0383	0.0347	0.0455	0.0359	0.0294	0.0269	0.0245

Appendix D - (Cont.) Interim Site-Specific Design Response Spectra

Table D-6 – Interim 1,250-Year Response Spectra

Frequency (Hz)	Spectral Acceleration (g) for Damping Ratio:									
	0.5% Horizontal	2% Horizontal	5% Horizontal	7% Horizontal	10% Horizontal	0.5% Vertical	2% Vertical	5% Vertical	7% Vertical	10% Vertical
0.25	0.0596	0.0475	0.0388	0.0356	0.0323	0.0424	0.0338	0.0276	0.0254	0.0230
0.238	0.0550	0.0443	0.0361	0.0332	0.0302	0.0396	0.0319	0.0261	0.0239	0.0217
0.227	0.0510	0.0414	0.0338	0.0310	0.0282	0.0372	0.0302	0.0246	0.0226	0.0205
0.217	0.0475	0.0389	0.0317	0.0291	0.0265	0.0349	0.0286	0.0234	0.0214	0.0195
0.208	0.0444	0.0366	0.0298	0.0274	0.0249	0.0330	0.0272	0.0222	0.0204	0.0185
0.2	0.0417	0.0347	0.0282	0.0259	0.0236	0.0312	0.0260	0.0212	0.0194	0.0177
0.182	0.0358	0.0303	0.0247	0.0227	0.0206	0.0274	0.0232	0.0189	0.0174	0.0158
0.167	0.0312	0.0269	0.0218	0.0201	0.0183	0.0244	0.0210	0.0171	0.0157	0.0143
0.154	0.0274	0.0240	0.0194	0.0179	0.0163	0.0218	0.0191	0.0155	0.0142	0.0130
0.143	0.0243	0.0216	0.0175	0.0161	0.0147	0.0197	0.0175	0.0142	0.0130	0.0119
0.133	0.0217	0.0195	0.0158	0.0145	0.0132	0.0178	0.0160	0.0130	0.0120	0.0109
0.125	0.0196	0.0179	0.0145	0.0133	0.0121	0.0164	0.0149	0.0121	0.0111	0.0101
0.118	0.0179	0.0165	0.0133	0.0123	0.0112	0.0151	0.0139	0.0112	0.0104	0.0094
0.111	0.0162	0.0151	0.0122	0.0112	0.0102	0.0139	0.0130	0.0105	0.0096	0.0088
0.1	0.0137	0.0130	0.0105	0.0097	0.0088	0.0121	0.0115	0.0092	0.0085	0.0078

Appendix E - Existing Facility Evaluation Criteria

If existing facilities need to be evaluated for compliance to DOE O 420.1C requirements, and if evaluation using site-specific natural phenomena hazards (NPHs) cannot show an existing facility to be in conformance with the acceptance criteria, then the methods for evaluating existing structures defined in DOE-STD-1020-2016 may be used.

NOTE: *Application of the methods for evaluating existing structures defined in DOE-STD-1020-2016 shall be subject to DOE approval.*

NOTE: *Prior to the detailed evaluation of existing facilities, an assessment should be made for the as-built condition. This assessment should include reviewing drawings and conducting site inspections to determine deviations from the drawings and any in-service deterioration. In-place strength of materials may be used when the information is available. Corrosive action and other aging processes should be considered as they affect the service life of the facility.*

Potential options for existing facilities are:

1. Upgrade easy-to-remedy deficiencies.

If an existing facility is close to meeting the design criteria, a slight increase in the annual risk to NPHs may be allowed. Hazard exceedence probabilities of twice the recommended values (i.e., half the return period) specified for new design may be used for seismic, wind, and ashfall loads, **provided that the resulting reduction in the hazard level is less than, or equal to, 20 percent.** Relief for flood loads is not permitted.

Figures D-3, D-4 provide the response spectra for the reduced hazard exceedence probabilities for evaluation of existing performance categories 3 (PC3) structures.

Table E-1 provides the peak ground acceleration for the reduced hazard exceedence probabilities for evaluation of existing PC1/NDC1 and PC2/NDC2 structures.

Table E-2 provides the wind velocity for the reduced hazard exceedence probabilities for evaluation of existing facilities.

Conduct a more rigorous evaluation of facility behavior to reduce conservatism that may have been introduced by simplified evaluation techniques. Alternatively, a probabilistic assessment of the facility may demonstrate that the performance goals for the facility may be met.

Change the use of the facility, provided there is an adequate technical basis, so that the facility falls into a performance category governed by less stringent requirements.

Strengthen the facility to provide resistance to hazard effects that meet the design criteria.

Appendix E - (Cont.) Existing Facility Evaluation Criteria

Table E-1 – Site Specific Response Spectra for Evaluation of Existing PC2/SDC2 and PC1/SDC1 Structures

	PC2/SDC2	PC1/SDC1
Mapped Spectral Acceleration	80%	80%

Table E-2 – Wind Velocity for Evaluation of Existing Facilities

	PC3/WDC3	PC2/WDC2	PC1/WDC1
Wind Speed	98	89 mph	80 mph
Missile (horizontal)	na	na	na
DOE-STD-1020-2002 Annual Exceedance Probability	$2x10^{-3}$	$2x10^{-2}$	$4x10^{-2}$

Table E-3 - Structural Loads & Airborne Concentration Due to Ash Fallout for Evaluation of Existing Facilities (80% of New Facilities)

PC/VDC	Annual Exceedance Probability	Ashfall Load(1) kg/m^2 (PSF)	Airborne Concentration (Initial) g/m3	Airborne Concentration (Resuspended) g/m3
1	2×10^{-3}	13 (2.6)	0.16	.13
2	1×10^{-3}	46 (9.4)	0.64	0.48
3	2×10^{-4}	90 (18.4)	1.2	0.88

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

Appendix F - Drillco Maxi-Bolt Design Requirements

Allowable Loads

Drillco Carbon Steel Maxi-Bolts
ASTM A193 Grade B7 High-strength

Anchor Diameter (Inches)	Tension (Pounds)	Shear Case 1 (Pounds)	Shear Case 2 (Pounds)
1/4	1,600	830	1,060
3/8	3,900	2,025	2,580
1/2	7,105	3,690	4,695
5/8	11,305	5,870	7,475
3/4	16,710	8,680	11,045
1	30,315	15,750	20,040
1 1/4	50,015	25,980	33,065

Allowable Loads

Drillco Class 1 Stainless Maxi-Bolts
ASTM A193 Grade B8 (Type 304) and B8M (Type 316)

Anchor Diameter (Inches)	Tension (Pounds)	Shear Case 1 (Pounds)	Shear Case 2 (Pounds)
3/8	1,105	575	730
1/2	2,025	1,050	1,340
5/8	3,230	1,675	2,135
3/4	4,780	2,480	3,160
1	8,655	4,495	5,720
1 1/4	14,290	7,420	9,445

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

Allowable Loads

Drillco Class 2 Stainless Maxi-Bolts
ASTM A193 Grade B8 (Type 304)

Anchor Diameter (Inches)	Tension (Pounds)	Shear Case 1 (Pounds)	Shear Case 2 (Pounds)
3/8	3,710	1,925	2,455
1/2	6,765	3,510	4,470
5/8	10,765	5,590	7,115
3/4	15,910	8,265	10,515
1	23,095	12,000	15,265
1 1/4	30,960	16,060	20,465

Allowable Loads

Drillco Class 2 Stainless Maxi-Bolts
ASTM A193 Grade B8M (Type 316)

Anchor Diameter (Inches)	Tension (Pounds)	Shear Case 1 (Pounds)	Shear Case 2 (Pounds)
3/8	3,525	1,830	2,330
1/2	6,425	3,335	4,245
5/8	10,225	5,310	6,760
3/4	16,115	7,850	9,990
1	23,095	12,000	15,265
1 1/4	30,960	16,080	20,465

NOTES:

1. Concrete Minimum Strength: **3,000 psi**.

Shear Case 1 applicable for grouted plates. **Shear Case 2** applicable for plates in contact with concrete surface.

Allowable values are premised on the concrete's ability to develop 100 percent of the stud bolt's minimum ultimate capacity. The allowable loads noted in the above tables may be assigned to each anchor in a multiple-anchor attachment. A single anchor used to anchor an attachment shall be designed for **one half** of the allowable loads noted. A single anchor is considered to be an anchor with no capability to redistribute its load to adjacent anchors.

Class **1 bolts** are those having yield strength of 30 ksi and an ultimate strength of 75 ksi. **Class 2 bolts** are high-strength bolts.

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

Embedment and Center-to-Center Spacing Requirements for Drillco Maxi-Bolts with ASTM A193 Grade B7 Carbon Steel Stud Bolts with up to six bolts in a rectangular pattern

ANCHOR PART NO.	ANCHOR STUD DIAMETER (Inches)	MAXIMUM ATTACHMENT THICKNESS (Inches)	EMBEDMENT (Inches)	3000 psi CONCRETE		4000 psi CONCRETE		5000 psi CONCRETE	
				Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)
MB-250-4 1/4-2	1/4	1.50	2	*4.50	4.50	*4.50	4.25	*4.50	4.00
MB-250-4 1/4-2 3/4	1/4	1.00	2 3/4	6.00	4.50	5.00	4.25	4.50	4.00
MB-375-6-3 1/2	3/8	2.50	3 1/2	*7.50	6.75	*7.50	6.25	*7.50	6.00
MB-375-6-4 1/2	3/8	1.50	4 1/2	9.00	6.75	7.50	6.25	6.50	6.00
MB-500-8 1/4-6	1/2	1.00	6	12.50	8.75	10.00	8.25	9.00	7.75
MB-500-11 1/4-8	1/2	2.00	8	8.50	8.75	7.00	8.25	6.00	7.75
MB-500-13 1/4-10	1/2	2.00	10	6.00	8.75	4.50	8.25	4.00	7.75
MB-625-10-7 1/2	5/8	1.25	7 1/2	16.00	11.00	13.00	10.25	11.50	9.75
MB-625-13-9 1/2	5/8	2.25	9 1/2	11.50	11.00	9.50	10.25	8.50	9.75
MB-625-16-12	5/8	2.75	12	8.00	11.00	6.50	10.25	5.50	9.75
MB-750-13 1/2-9 1/4	3/4	2.75	9 1/4	18.50	13.00	15.00	12.25	13.50	11.75
MB-750-16 1/2-11 1/2	3/4	3.50	11 1/2	14.00	13.00	12.00	12.25	10.50	11.75
MB-750-18 1/2-13	3/4	4.00	13	12.00	13.00	10.00	12.25	8.50	11.75
MB-1000-16 1/2-12 1/2	1	2.00	12 1/2	24.50	17.50	20.00	16.25	18.00	15.50
MB-1000-22 1/2-16 1/2	1	3.50	16 1/2	17.00	17.50	14.50	16.25	12.50	15.50
MB-1000-26 1/2-20 1/2	1	3.50	20 1/2	12.00	17.50	9.50	16.25	7.50	15.50
MB-1250-20-16	1 1/4	1.75	16	31.50	22.00	26.00	20.50	23.00	19.25
MB-1250-30-23	1 1/4	5.00	23	19.50	22.00	16.00	20.50	14.00	19.25
MB-1250-37-29 1/2	1 1/4	5.50	29 1/2	12.00	22.00	8.50	20.50	6.50	19.25

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

Embedment and Center-to-Center Spacing Requirements for Drillco Maxi-Bolts with ASTM A193 Grade B8 (Type 304) and B8M (Type 316) Class 1 Stainless Stud Bolts with up to six bolts in a rectangular pattern

ANCHOR PART NO.	ANCHOR STUD DIAMETER (Inches)	MAXIMUM ATTACHMENT THICKNESS (Inches)	EMBEDMENT (Inches)	3000 psi CONCRETE		4000 psi CONCRETE		5000 psi CONCRETE	
				Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)
SAMB-375-6-3 1/2	3/8	2.50	3 1/2	6.50	5.25	5.50	4.75	5.00	4.50
SAMB-375-6-4 1/2	3/8	1.50	4 1/2	5.00	5.25	4.00	4.75	4.00	4.50
SAMB-500-8-5	1/2	2.00	5	8.50	7.00	7.00	6.50	6.50	6.00
SAMB-500-10-6 1/2	1/2	2.50	6 1/2	6.00	7.00	6.00	6.50	6.00	6.00
SAMB-625-10-6	5/8	2.75	6	11.00	8.50	9.50	8.00	8.50	7.50
SAMB-625-12-8	5/8	2.75	8	8.00	8.50	8.00	8.00	6.00	7.50
SAMB-750-11-7	3/4	2.50	7	14.50	10.25	12.00	9.50	10.50	9.00
SAMB-750-13-9 1/2	3/4	2.00	9 1/2	10.00	10.25	10.00	9.50	8.00	9.00
SAMB-1000-14-9 1/2	1	2.50	9 1/2	19.00	13.75	16.00	12.75	14.50	12.00
SAMB-1000-16-12	1	2.00	12	14.00	13.75	14.00	12.75	12.00	12.00
SAMB-1250-16-12	1 1/4	1.75	12	25.50	17.00	20.50	15.75	18.50	15.00
SAMB-1250-22-16	1 1/4	3.75	16	18.00	17.00	16.00	15.75	14.00	15.00

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

Embedment and Center-to-Center Spacing Requirements for Drillco Maxi-Bolts with ASTM A193 Grade B8 (Type 304) Class 2 Stainless Stud Bolts with up to six bolts in a rectangular pattern

ANCHOR PART NO.	ANCHOR STUD DIAMETER (Inches)	MAXIMUM ATTACHMENT THICKNESS (Inches)	EMBEDMENT (Inches)	3000 psi CONCRETE		4000 psi CONCRETE		5000 psi CONCRETE	
				Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)
SAMB-375-6-4 1/2	3/8	1.50	4 1/2	9.00	6.75	7.50	6.25	6.50	6.00
SAMB-500-8-6	1/2	1.00	6	12.50	8.75	10.00	8.25	9.00	7.75
SAMB-500-11-8	1/2	2.00	8	8.50	8.75	7.00	8.25	6.00	7.75
SAMB-500-13-10	1/2	2.00	10	6.00	8.75	4.50	8.25	4.00	7.75
SAMB-625-10-7 1/2	5/8	1.25	7 1/2	16.00	11.00	13.00	10.25	11.50	9.75
SAMB-625-13-9 1/2	5/8	2.25	9 1/2	11.50	11.00	9.50	10.25	8.50	9.75
SAMB-625-16-12	5/8	2.75	12	8.00	11.00	6.50	10.25	5.50	9.75
SAMB-750-13-9 1/4	3/4	2.75	9 1/4	18.50	13.00	15.00	12.25	13.50	11.75
SAMB-750-16-11 1/2	3/4	3.50	11 1/2	14.00	13.00	12.00	12.25	10.50	11.75
SAMB-750-18-13	3/4	4.00	13	12.00	13.00	10.00	12.25	8.50	11.75
SAMB-1000-16-12	1	2.00	12	24.00	16.75	20.00	15.75	16.00	14.75
SAMB-1000-22-16	1	4.00	16	16.00	16.75	14.00	15.75	12.00	14.75
SAMB-1000-26-20	1	4.00	20	10.00	16.75	8.00	15.75	6.00	14.75
SAMB-1250-20-15	1 1/4	3.00	15	28.00	20.00	22.00	18.75	20.00	17.75
SAMB-1250-25-20	1 1/4	3.00	20	18.00	20.00	14.00	18.75	12.00	17.75
SAMB-1250-30-25	1 1/4	3.00	25	8.00	20.00	8.00	18.75	6.00	17.75

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

Embedment and Center-to-Center Spacing Requirements for Drillco Maxi-Bolts with ASTM A193 Grade B8M (Type 316) Class 2 Stainless Stud Bolts with up to six bolts in a rectangular pattern

ANCHOR PART NO.	ANCHOR STUD DIAMETER (Inches)	MAXIMUM ATTACHMENT THICKNESS (Inches)	EMBEDMENT (Inches)	3000 psi CONCRETE		4000 psi CONCRETE		5000 psi CONCRETE	
				Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)	Minimum Center to Center Spacing (Inches)	Minimum Edge Distance (Inches)
SAMB-375-6-3 1/2	3/8	2.50	*3.5	* 7.50	6.25	*7.50	5.75	* 7.50	5.50
SAMB-375-6-4 1/2	3/8	1.50	4 1/2	9.00	6.25	7.00	5.75	6.00	5.50
SAMB-500-8-6	1/2	1.00	6	12.00	8.25	10.00	7.75	8.00	7.25
SAMB-500-11-8	1/2	2.00	8	8.00	8.25	6.00	7.75	6.00	7.25
SAMB-500-13-10	1/2	2.00	10	6.00	8.25	4.00	7.75	4.00	7.25
SAMB-625-10-7 1/2	5/8	1.25	7 1/2	16.00	10.25	12.00	9.75	10.00	9.00
SAMB-625-13-9 1/2	5/8	2.25	9 1/2	10.00	10.25	8.00	9.75	8.00	9.00
SAMB-625-16-12	5/8	2.75	12	8.00	10.25	6.00	9.75	4.00	9.00
SAMB-750-13-9 1/4	3/4	2.75	9 1/4	18.00	12.50	14.00	11.50	12.00	11.00
SAMB-750-16-11 1/2	3/4	3.50	11 1/2	14.00	12.50	12.00	11.50	10.00	11.00
SAMB-750-18-13	3/4	4.00	13	12.00	12.50	10.00	11.50	8.00	11.00
SAMB-1000-15-11	1	2.00	11	22.00	15.75	18.00	14.75	16.00	13.75
SAMB-1000-18-14	1	2.00	14	16.00	15.75	14.00	14.75	12.00	13.75
SAMB-1000-20-16	1	2.00	16	12.00	15.75	10.00	14.75	8.00	13.75
SAMB-1250-18-14	1 1/4	2.00	14	28.00	19.00	24.00	17.75	20.00	16.75
SAMB-1250-24-18	1 1/4	4.00	18	22.00	19.00	18.00	17.75	14.00	16.75
SAMB-1250-28-22	1 1/4	4.00	22	18.00	19.00	14.00	17.75	10.00	16.75

*Recommendation based on independent laboratory testing. All other embedment and center to center recommendations based on design by analysis provisions of ACI 349-97, Appendix B.

NOTES:

1. Maximum attachment thickness is based on torque tensioning of anchor. Any lesser attachment thickness may be used. Where the anchor is to be hydraulically tensioned, maximum attachment thicknesses will be reduced by one stud diameter.

2. Consideration of stress area reduction for limited concrete depth is not reflected in the above table. Minimum concrete depth = anchor embedment plus (center-to-center spacing/2).

3. Maxi-Bolt part numbers are specified as follows: MB-Diameter Series Number-Overall Length-Sleeve Length (combined expansion sleeve and distance tube lengths).

4. Minimum edge distances quoted are for shear or combined tension and shear. For tension loading, edge distance may be reduced to 75 percent of given value.

Appendix F - (Cont.) Drillco Maxi-Bolt Design Requirements

5. Allowable values are limited to a maximum of six bolts in a two-row, three-column, or three-row, two-column arrangement. Allowable values may also be used for anchors placed in a single line and separated from other anchor lines by a minimum distance of two times the anchor embedment length.

6. In-place embedment length is determined by subtracting the over-all length (second number shown in Anchor Part No. column) from the exposed projection.