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1. Purpose

The purpose of this Standard is to provide seismic design requirements and guidelines for all applicable structures at PPPL. The seismic design requirements shall meet the requirements outlined in this Standard and as interpreted through Department of Energy Order 420.1C. As a result, all equipment, structures and experimental projects across PPPL shall be designed to safely withstand the expected seismic loads.

This standard provides the background and process for determining the Natural Phenomena Hazards (NPH) Design analysis methods and criteria at PPPL for new structures or those undergoing major modification (greater than 50% of their original value or substantially change the existing safety basis for the facility).

2. Applicability

This Standard applies to the site as it is currently, if nuclear facilities are introduced, it will have to be re-assessed.

This Standard applies to all structures across the PPPL complex, including C-Site and D-Site. A “*structure*” is defined as any building and the equipment/materials/property housed within those buildings or support structures, be they permanent or temporary.

PPPL recognizes that the scope of this definition of “*structure*” may be very broad. The following structures may be excluded from the requirements of this standard if either or both of the following criteria are satisfied and documented:

- Any structure or device that is mounted directly to the floor and presents no risk to personnel during a seismic event.
- Any system meeting another national or state recognized standard or code with the written approval of a licensed Civil Engineer.

3. Background

While PPPL is not located in a seismically active area, most buildings throughout the PPPL Complex were designed and built to the Uniform Building Code (UBC), the code of record during initial construction as first published in 1927 at the International Conference of Building Officials. In the unlikely event of a serious earthquake, the code provided guidelines to minimize principle hazards including damage to buildings and/or structures, and injury to nearby workers from falling debris. Updated editions of the code were published approximately every three years until 1997, when the final edition was released. The UBC was succeeded by the International Building Code (IBC) published by the International Code Council in 2000. PPPL has employed the best engineering and architectural practices available at the time of design for all new structures to ensure sufficient safety factors capable of withstanding the expected NPH.

4. Design Guidance for Buildings and Other Structures

ASCE 7 provides the minimum design loads for buildings and other structures. The analysis technique presented herein is the result of the distillation of all applicable factors and coefficients in the IBC into a simple static analysis applicable to experimental equipment in a PPPL test cell.

There are three test cells at PPPL including one in the C-Site CS building and two at D-Site, the TFTR and NSTX (aka "hot cell") test cells. While all three test cells have a basement, they compensate structural integrity with a massive floor system with a strong column system with each column capable of 2500 PSF. All three floors are also well coupled to the grade. Elevation calculations for any equipment mounted to the test cell floors may be considered at grade; however,

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the equipment frequency response must be calculated and factored in to the design. This analysis is to be applied when the equipment or component in question can pose a physical hazard to the health and welfare of an employee or the public. Per the 2015 IBC Chapter 16, “every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 and Appendix 11A. The seismic design category for a structure is permitted to be determined in accordance with IBC Section 1613 or ASCE 7.”

This is the minimum standard. Over and above this minimum standard, the remaining body of this document interprets the applicable sections of the code for mechanical equipment including experimental devices at PPPL and may be applied as required to ensure some level of operability of critical equipment (Category A-1), that support the PPPL mission after a seismic event.

5. Specific Requirements

5.1 Applicable Design Criteria

The PPPL soil site classification is "C" “very dense soil and soft rock” per geologist Rob Sheneman (Attachment A) and NV5 geotechnical evaluation report (reference 13 paragraph 6.5). The PPPL seismic design category (SDC) is "B" based on ASCE 7-10 section 11.6 for structures with risk category I, II, or III and a short period response acceleration between 0.167g and 0.33g (PPPL S_{DS} is 0.189g).

5.2 Design

New structure or mechanical equipment designs or those undergoing major modification (greater than 50% of their original value) shall follow the requirements listed within this standard.

5.3 Seismic Design for an Experimental Device

The D-Site experimental complex structures have been determined to have adequate capacity to remain functional under the overall loads due to an earthquake with a horizontal ground acceleration of up to 0.13g.

5.4 Calculation of Mapped Acceleration Parameters based on ASCE 7-10 and IBC 2012/2015

Attachment B contains the current (as of 2018) site calculations of the acceleration parameters as listed on the USGS website based on both the ASCE 7-10 and the IBC 2012/2015. Both the ASCE-7-10 and IBC 2012/2015 calculations agree.

The appropriate ASCE 7-10 sections showing the calculation is quoted below to assist in understanding the process.

“ASCE 7-10 Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 and 1.3 to obtain S_s and S_1 respectively. Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1: $S_s = 0.237$ g

From Figure 22-2: $S_1 = 0.066$ g”

“ASCE 7-10 Section 11.4.3 — Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCER) Spectral Response Acceleration Parameters [are provided below].

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Table 11.4-1: Site Coefficient F_a

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1	1
D	1.6	1.4	1.2	1.1	1
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use Straight-Line Interpolation for Intermediate Values of S_S For Site Class "C" and $S_S = 0.237$ g, $F_a = 1.200$ Table 11.4-2: Site Coefficient F_v

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at 1-s Period				
	$S_I \leq 0.10$	$S_I = 0.20$	$S_I = 0.30$	$S_I = 0.40$	$S_I \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use Straight-Line Interpolation for Intermediate Values of S_I For Site Class "C" and $S_I = 0.066$ g, $F_v = 1.700$

Equation (11.4-1): $S_{MS} = F_a S_S = 1.200 \times 0.237 = 0.284$ g

Equation (11.4-2): $S_{MI} = F_v S_I = 1.700 \times 0.066 = 0.112$ g

Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4-3): $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.284 = 0.189$ g

Equation (11.4-4): $S_{DI} = \frac{2}{3} S_{MI} = \frac{2}{3} \times 0.112 = 0.075$ g

Section 11.4.5 — Design Response Spectrum

From Figure 22-12 $T_L = 6$ seconds

Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 $PGA = 0.135$

Equation (11.8-1): $PGA_M = F PGA = 1.200 \times 0.135 = 0.163$ g

$PGA_M = 0.163$ g < $S_{DS} = 0.189$ g

[End of quoted Section from ASCE 7-10]**Conclusion:****The PPPL Site Seismic Design Ground Acceleration (S_{DS}) is 0.189 g for new and major modification construction.**

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5.5 Application of ASCE 7-10 for Seismic Loads on Mechanical Equipment Including Experimental Devices and Associated Tooling

ASCE 7-10 provides the minimum design loads for buildings and other structures at the writing of this standard. It covers many types of structures, systems, and devices. The sections below are provided as a general overview and cannot serve alone as the basis for design.

ASCE 7-10 chapters can be generally sub-categorized as follows:

5.5.1. ASCE 7-10 Chapter 1

This Chapter provides guidance for the determination of the risk category. Per Table 1.5-1 Buildings and structures at PPPL fall into Risk Category II except those designated as Occupancy Category IV facilities, which include:

- (1) Fire, rescue, ambulance, and emergency vehicle garages
- (2) Designated earthquake, hurricane or other emergency shelters
- (3) Designated emergency preparedness, communication, and operations centers and other facilities required for emergency response
- (4) Ancillary structures required for operation of Occupancy Category IV facilities during an emergency including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment.
- (5) Water storage facilities and pump structures required to maintain water pressure for fire suppression.

5.5.2. ASCE 7-10 Chapter 11

This Chapter provides general seismic design criteria including the seismic design category. ASCE 7-10 Chapter 11 Table 11.6-1 indicates that for Seismic Design Category (SDC) Based on Short Period Response Acceleration Parameter equipment in Risk Category I, II, or III with an S_{DS} value of 0.189g, the SDC is "B". Table 11.6-2 also indicates that for SDC based on 1-S Period Response Acceleration, the PPPL SDC is "B".

5.5.3. ASCE 7-10 Chapter 12

This Chapter provides seismic analysis and design procedures to be used in the design of building structures and their members. This standard assumes that a competent registered architectural engineering firm will perform design of new building structures at PPPL.

5.5.4. ASCE 7-10 Chapter 15

This Chapter establishes minimum design criteria for non-building structures include all self-supporting structures that carry gravity loads and that may be required to resist the effects of earthquake such as elevated tanks, vessels, bins or hoppers; flat-bottom ground-supported tanks; trussed towers (freestanding or guyed), cooling towers, telecommunication towers, guyed stacks, chimneys etc.

5.5.5. ASCE 7-10 Chapter 13 with detailed description and calculation

This Chapter establishes minimum design criteria for nonstructural components that are permanently attached to structures and for their supports and attachments such as HVAC system components, engines, turbines, pumps, compressors, and pressure vessels, piping or ductwork distributions systems, or other mechanical or electrical components such as PPPL experimental devices deemed by the project to warrant seismic design.

- ASCE Section 13.1.2 states, “for the purposes of this chapter, nonstructural components shall be assigned to the same seismic design category as the structure that they occupy or to which they are attached.”
- ASCE Section 13.1.3 provides the component seismic importance factor (I_p), which is generally equal to 1.0 for our mechanical equipment and experimental devices. Life safety items have an I_p greater than 1.0.
- ASCE Section 13.1.4 lists those nonstructural components that are exempt from the requirements of this section. Technically, mechanical and electrical components in Seismic Design Category "B" are exempt from seismic design requirements. Also exempt are mechanical and electrical components in Seismic Design Category "C" provided that the component importance factor, I_p , is equal to 1.0.
- ASCE Section 13.3 provides the seismic demands on nonstructural components such as our mechanical equipment and experimental devices. Paragraph 13.3.1 Seismic Design Force provides the calculation for “the horizontal seismic design force (F_p) to be applied at the component’s center of gravity and distributed relative to the component’s mass distribution and distributed relative to the component’s mass distribution and shall be determined in accordance with Eq. 13.3-1.” For convenience this calculation is provided below. The appropriate section and table within ASCE 7 must be referred to for correct factor values.
- Each component must be analyzed to determine its frequency response with the calculated seismic input and designed accordingly.
- I_p is the importance factor based on life safety. Non-life safety items have an I_p of 1.0.
- R_p is the response modification factor. The more the component can deform the higher the value. For low deformability equipment an R_p of 1.5 should be used. R_p varies greatly for high deformability. For simplicity an R_p of 1.5 can be used for conservative estimates.
- a_p is the amplification factor. The more flexible the component the higher the value. For rigidly supported equipment an a_p of 1.0 should be used. For flexibly supported equipment an a_p of 2.5 should be used.
- Since the components are located at the ground floor, z is taken as 0. Base shear is taken at grade. All subgrade components also have a z of 0.
- S_{DS} is 0.189g per USGS data (attached).
- As such, equation 13.3-1 equals $0.05 W_p$ (component weight) for rigidly supported equipment and $0.13 W_p$ for flexibly supported equipment. However, equation 13.3-3 does not allow the design force to be below $0.06 W_p$.

$$F_p = \frac{0.4a_p S_{DS} W_p}{(R_p / I_p)} \left(1 + 2 \frac{z}{h}\right) \quad (13.3-1)$$

F_p is not required to be taken as greater than

$$F_p = 1.6 S_{DS} I_p W_p \quad (13.3-2)$$

and F_p shall not be taken as less than

$$F_p = 0.3 S_{DS} I_p W_p \quad (13.3-3)$$

where

F_p	[lb]	= seismic design force
S_{DS}	[g]	= spectral acceleration, short period, as determined from Section 11.4.4
a_p	[ND]	= component amplification factor that varies from 1.00 to 2.50 (select appropriate value from Table 13.5-1 or 13.6-1)
I_p	[ND]	= component importance factor that varies from 1.00 to 1.50 (see Section 13.1.3)
W_p	[lb]	= component operating weight
R_p	[ND]	= component response modification factor that varies from 1.00 to 12 (select appropriate value from Table 13.5-1 or 13.6-1)
z	[ft]	= height in structure of point of attachment of component with respect to the base. For items at or below the base, z shall be taken as 0. The value of (z/h) need not exceed 1.0
h	[ft]	= average roof height of structure with respect to the base

6. Additional Requirements for PPPL as a DOE Facility (see Attachment C)

6.1 DOE O 420.1C – “Facility Safety”

This Standard governs safety requirements at all DOE facilities. Per Attachment A, existing PPPL facilities do not require a 10-year NPH assessment unless they meet the requirements of an Occupancy Category IV facility. PPPL is required by the Department of Energy to meet the seismic requirements of DOE-STD-1020 Performance Category 1 (PC-1) for Seismic Use Group I. Interpretation of these requirements leads to the adoption of the International Building Code, (IBC).

6.2 DOE STD-1020-2016 – “Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities”

This Standard states that any structures, systems & components (SSCs) whose failure would cause more than three (3) month downtime or impact to the programmatic mission of a facility (Category A-1 per PPPL QAPD) or may cause fatality or serious injuries to in-facility workers, shall be placed in PC-1. All other systems are placed in PC-0 and thus have no seismic design requirements. DOE-STD-1021-93 (“Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components”) was replaced by DOE-STD-1020-2012, which was revised and released as DOE-STD-1020-2016.

6.3 International Building Code (IBC)

Interpretation of the DOE requirements outlined in Sections 6.1 and 6.2 leads to the adoption of the International Building Code, (IBC), with PPPL adopting a 2/3 Maximum Considered Earthquake (MCE, site specific) as the standard requirement.

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7. Applicability to Existing Buildings

7.1 Existing Buildings

In Attachment A, PPPL examined the requirements of DOE O420.1C ("Facility Safety") to determine the specific requirements to be followed by PPPL in assessing the natural phenomena hazards (NPH) of existing buildings as of the date of analysis, May 2013. At present, PPPL has no Category 1, 2 or 3 nuclear facilities. Starting with the DOE Order itself, PPPL traced the thread of requirements through several referenced standards and reached a conclusion (at the end of this paper) on what is required for PPPL to be in compliance with the Order for NPH assessments of existing buildings. Based on Exemption b of RP-08 (Section 1.3), it was concluded that existing PPPL facilities do not require a 10-year natural phenomena hazard (NPH) assessment unless they meet the requirements of an Occupancy Category IV facility (i.e., by satisfying at least one of criteria 1-5 in Section 5.5.1 of this document). Any PPPL facility designated Occupancy Category IV would require a seismic evaluation (and possible retrofitting) if a project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 50 percent of the replacement value of the building. This conclusion does not apply to any new facility construction.

7.2 Public Access Buildings

As the primary intent of the IBC is to provide for the protection of the public in the event of an earthquake, seismic requirements were applied to all public-access buildings at PPPL. For restricted/badge-entry access (non-public) areas on the other hand, a relaxed seismic requirement may be employed. However, PPPL continues to follow code requirements.

7.3 D-Site Complex

The seismic (and other NPH) requirements for the original TFTR complex and their derivation can be found in the TFTR FSAR (Section 2.5). Most of the complex was designed for the "Most Probable Earthquake", 0.07g maximum horizontal acceleration, while the Tritium Area was designed for the "Most Intense Earthquake", 0.13g max horizontal acceleration.

Seismic qualification of the NSTX Test Cell (NTC)

The NTC, along with the rest of the D-Site experimental complex structures, had been determined in preparation for TFTR Tritium operations by EQE Consulting, an engineering firm that specializes in Natural Hazard Analysis, to have adequate capacity to remain functional under the overall loads due to an earthquake with a horizontal ground acceleration of 0.13g.

Seismic qualification of the NSTX Torus and Platforms

The NSTX torus structure was designed to satisfy the Department of Energy (DOE) standard for natural phenomena hazard (NPH) events per DOE STD 1020-2002. Only the effects of earthquakes are considered for the NSTX torus structure. The DOE standard required the use of Performance Categories (PC) to specify the relative risk, environmental impact, importance, and cost of each facility. The assessment for seismic loading and evaluation for seismic response was followed to determine that the design of the structure is acceptable with respect to the performance goals. On this basis the seismic performance goal for the NSTX torus structure places it in NPH Performance Category 1 (PC-1). For the PPPL Site, a PC-1 earthquake had a maximum horizontal ground acceleration of 0.09g prior to this standard. The NSTX platforms were designed for 0.13g, the seismic design of the original NSTX torus structure. Equipment associated with NSTX are designed and built consistent with these requirements.

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7.4 Components

Seismic analysis of components and equipment is not required by the IBC (see IBC 2000 Section 1621.1.1) in non-public/badge/controlled experimental areas since they do not pose a threat to the health and welfare of the public. However DOE-STD-1021-93 (see Section 6.2) still applied requiring the definition of a PC-1 earthquake. For the PPPL Complex, a PC-1 earthquake had a maximum horizontal ground acceleration of 0.09g. This is the design acceleration for existing PPPL structures. Per the current Standard DOE-STD-1020-2016 PPPL is categorized as a non-nuclear facility and as such categorization and design of SSCs subjected to NPH loads shall be performed using the criteria.

8. References

1. "Uniform Building Code (UBC), 1991 Edition" - <http://digitalassets.lib.berkeley.edu/ubc/>
2. IBC-2015, "International Building Code (IBC-2015)" - <https://codes.iccsafe.org/public/document/toc/542/>
3. ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures" - <https://www.asce.org/asce-7/>
4. DOE O 420.1C, "Facility Safety" - <https://www.directives.doe.gov/directives-documents/400-series/0420.1-BOrder-c>
5. DOE STD 1020-2016, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities" - <https://www.standards.doe.gov/standards-documents/1000/1020-astd-2016/@@images/file>
6. DOE STD 1021-93, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components" - <https://www.standards.doe.gov/standards-documents/1000/1021-astd-1993-CN1-1996-reaff-2002/@@images/file>
7. USGS U.S. Seismic Design Maps - <https://earthquake.usgs.gov/hazards/designmaps/usdesign.php>
8. NSTX-U SAD-R6 - http://nstx.pppl.gov/DragNDrop/Operations/NSTXU%20SADR6/NSTXU_SADR6_Ch1-3.pdf
9. IBC-2015 International Building Code (Chapter 16 SECTION 1613 EARTHQUAKE LOADS): <https://codes.iccsafe.org/public/document/code/542/9680723>
10. U.S. Department of Energy, "Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites", DOE-STD-1024-92 December, 1992
11. USGS website: <https://earthquake.usgs.gov/designmaps/us/application.php>
12. Quality Assurance Program Description (QAPD)
13. "Geotechnical Evaluation Report Princeton Plasma Physics Lab - Infrastructure and Operational Improvements", August 28, 2015 NV5-Northeast Inc. Project Number: 113515-01461
14. PPPL Calculation ENG-CALC-#300 Calculation of Mapped Acceleration Parameters based on ASCE 7-10 and IBC 2012/2015

9. Attachments

- A. Requirements for Reassessment of Existing PPPL Facilities (performed by Jerry Levine, ES&H Head, 5/24/13)
- B. USGS Design Map Summary using 2012/2015 IBC
- C. General Requirements for PPPL as a DOE Facility

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**Attachment A. Requirements for Reassessment of Existing PPPL Facilities
(performed by Jerry Levine, ES&H Head, 5/24/13)**

PPPL examined the requirements of DOE O420.1C ("Facility Safety") to determine the specific requirements to be followed by PPPL in assessing the natural phenomena hazards (NPH) of existing buildings as of the current date (May 2013). At present, PPPL has no Category 1, 2 or 3 nuclear facilities. Starting with the DOE Order itself, PPPL traced the thread of requirements through several referenced standards and reached a conclusion (at the end of this paper) on what is required for PPPL to be in compliance with the Order for NPH assessments of existing buildings. Key inputs to the conclusion are noted in bold. This conclusion does not apply to any new facility construction.

- DOE O420.1C, CRD, Chapter IV, 3d.

(1) Existing facility or site NPH assessments must be reviewed at least every 10 years for any significant changes in data, criteria, and assessment methods that would warrant updating the assessments. ***Section 9.2 of DOE-STD-1020-2012 contains criteria and guidance for performing these reviews.*** The review results, along with any recommended update actions, must be submitted to the head of the field element. If no update is necessary, this result must be documented following the review.

(2) If a new assessment of NPH demands indicates deficiencies in existing SSC design, a plan for upgrades must be developed and implemented on a prioritized schedule, based on the safety significance of the upgrades, time or funding constraints, and mission requirements. Section 9.3 of DOE-STD-1020-2012 contains guidance on performing upgrade evaluations.

- DOE-STD-1020-2012.

Section 9.0 ("Evaluation and Modification of SSCs in Existing Facilities"), states that this section (which includes Sections 9.2 and 9.3 referenced in DOE O420.1C) ***"provides criteria and guidance for existing hazard categories 1, 2 and 3 nuclear facilities with SSCs in NDC-3 or higher"***. It further indicates that ***"criteria and guidance for evaluation of existing nuclear, radiological, and chemical hazard facilities with SSCs in NPH Design Categories below NPH Design Category 3 is given in Section 2.1.4."***

Since PPPL currently has no hazard category 1, 2 or 3 nuclear facilities, the criteria and guidance of Section 2.1.4 is applicable. **Section 2.1.4 states:**

"To comply with Public Law 102-614 and Executive Order 12941, Seismic Safety of Existing Federally Owned or Leased Buildings, the guidelines provided in the Interagency Committee on Seismic Safety in Construction's (ICSSC) RP-8, Standards of Seismic Safety for Existing Federally Owned and Leased Buildings, shall be used to:

- (1) determine when a seismic evaluation and retrofitting of an existing non-nuclear facility will be necessary; and***
- (2) establish the evaluation and mitigation requirements.***

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- ICSSC RP-8 (NIST GCR 11-917-12).
Section 3.1 states that “*any buildings that do not meet the exemption criteria defined in Section 1.3 and that are in a triggering situation described in Section 2.1*” shall have a seismic evaluation and possible retrofiting. The exemption criteria in Section 1.3 are:
 - a. All buildings located where $S_{DS} < 0.167$ g and $S_{DI} < 0.067$ g; where S_{DS} and S_{DI} are the Design Earthquake Spectral Response Acceleration Parameters at short periods and at a 1 second period, respectively, as defined in ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI, 2005).
 - b. All buildings located where $S_{DS} < 0.330$ g and $S_{DI} < 0.133$ g unless designated for an occupancy-based performance objective;**
 - c. Detached one- and two-family dwellings located where $S_{DS} < 0.4$ g unless designated for an occupancy-based performance objective;
 - d. Building structures that are intended only for incidental human occupancy or that are occupied by persons for a total of less than 2 hours a day, unless designated for an occupancy-based performance objective;
 - e. One-story buildings of steel light frame or wood construction with areas less than 280 m² (3000 ft²), unless designated for an occupancy-based performance objective;
 - f. Buildings scheduled for demolition;
 - g. Buildings in foreclosure;
 - h. Non-Federally owned buildings leased by the Federal Government with temporary short-term leases;
 - i. Non-Federally owned buildings containing a total area leased by the Federal Government of less than 930 m² (10,000 ft²) where $S_{DS} < 0.50$ g and $S_{DI} < 0.20$ g; or,
 - j. Buildings designated by the agency as having a remaining useful life of, or fulfilling an agency need for, less than five years.

Section 2.1 covers triggering situations requiring evaluation and potential mitigation. *For existing buildings, this section states that at a minimum, a building shall be evaluated, and any unacceptable risks posed by the building shall be mitigated when any of the following occur:*

- a. A change in the building’s function that results in an increase, as determined by the agency, in the building’s level of use, importance, or occupancy;
- b. *For buildings assigned to Seismic Design Category (SDC) C (as defined by ASCE/SEI 7-05), a project is planned that significantly extends the building’s useful life through alterations or deferred maintenance that total more than 50 percent of the replacement value of the building;*
- c. For a building assigned to SDC D, E or F (as defined by ASCE/SEI 7-05), a project is planned that significantly extends the building’s useful life through alterations or deferred maintenance that total more than 30 percent of the replacement value of the building;
- d. The building or part of the building has been damaged as a result of fire, wind, earthquake, or another cause to the extent that, in the judgment of the agency based on evaluations performed by qualified registered professional engineers, significant structural degradation of the building’s vertical- or lateral-load-carrying systems has occurred;
- e. The building is designated by the agency to pose an exceptionally high risk to occupants or to the public at large; or
- f. The building is added to the Federal inventory through purchase or donation after adoption of RP-8.

- ASCE/SEI 7-2005 [note these values are based on ASCE 7-2005 and while close are somewhat less than the ASCE 7-2010 values above.]

To decide whether an exemption or triggering situation cited in RP-8 exists, the Design Earthquake Spectral Response Acceleration Parameters S_{DS} and S_{D1} must be determined for the PPPL site. This requires application of Chapter 11 of SEI 7-05 (“Seismic Design Criteria”), which has

$$S_{DS} = \frac{2}{3} S_{MS}; \quad S_{D1} = \frac{2}{3} S_{M1}$$

where S_{MS} and S_{M1} are the Adjusted Maximum Considered Earthquake (MCE) spectral response acceleration parameters for short periods and 1 second, respectively. Chapter 11 further has

$$S_{MS} = F_a S_s; \quad S_{M1} = F_v S_1$$

where S_s and S_1 are the mapped MCE spectral response acceleration parameters for short periods and 1 second, respectively, and F_a and F_v are site coefficients defined in Tables 11.4-1 and 11.4-2. S_s and S_1 for the PPPL site are determined from Figures 22-1 and 22-2. From these figures,

$S_s = 0.30g$ and $S_1 = 0.06g$.

The site coefficients in Tables 11.4-1 and 11.4-2 depend on the values of S_s and S_1 and a Site Class designation (A-F) that is derived from Table 20.3-1 (“Site Classification”) and is based on site geologic conditions. *From conversations with Rob Sheneman (a professional geologist) and documentation on soil conditions (obtained during TFTR and CIT design activities), the Site Class designation for PPPL was determined to be Class C.* Accordingly, F_a is 1.2 and F_v is 1.7 for PPPL using Tables 11.4-1 and 11.4-2, respectively. Thus,

$$S_{MS} = 1.2 \times 0.3g = 0.36g$$

$$S_{M1} = 1.7 \times 0.06g = 0.102g$$

and,

$$S_{DS} = \frac{2}{3} \times 0.36g = 0.24g$$

$$S_{D1} = \frac{2}{3} \times 0.102g = 0.068g$$

It is also noted that Section 1 of RP-8 references SEI 7-05 in the following manner: “ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI, 2005), as modified by Part 1 of P-750, *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* (FEMA, 2009)”. The modifications in P-750 indicate that S_s is determined as the lesser value of the following equations:

$$S_s = C_{RS} \cdot S_{SUH}$$

$$S_s = S_{SD}$$

and S_1 is determined as the lesser value of the following equations:

$$S_1 = C_{R1} \cdot S_{1UH}$$

$$S_1 = S_{1D}$$

Where

- S_{SD} = mapped deterministic, 5 percent damped, spectral response acceleration parameter at short periods,
 S_{SUH} = mapped uniform-hazard, 5 percent damped, spectral response acceleration parameter at short periods,
 C_{RS} = mapped value of the risk coefficient at short periods,
 S_{1D} = mapped deterministic, 5 percent damped, spectral response acceleration parameter at a period of 1 second.

These parameters are determined from Figures 22-1 through 22-6 of P-750. Using these figures, $S_s = 0.2175g$ and $S_I = 0.048g$. Thus,

$$S_{MS} = 1.2 \times 0.2175g = 0.261g$$

$$S_{MI} = 1.7 \times 0.048g = 0.0816g$$

and, $S_{DS} = 2/3 \times 0.261g = 0.174g$

$$S_{DI} = 2/3 \times 0.0816g = 0.0544g$$

Using these values in Section 11.6, specifically in Tables 11.6-1 and 11.6-2, the Seismic Design Category (SDC) for PPPL structures can be determined using "Occupancy Categories" in Table 1-1. *Accordingly, all PPPL buildings would be assigned to SDC B except those designated as Occupancy Category IV facilities*, which (per Table 1-1) include

- (1) Fire, rescue, ambulance, and emergency vehicle garages
- (2) Designated earthquake, hurricane or other emergency shelters
- (3) Designated emergency preparedness, communication, and operations centers and other facilities required for emergency response
- (4) Ancillary structures required for operation of Occupancy Category IV facilities during an emergency including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment.
- (5) Water storage facilities and pump structures required to maintain water pressure for fire suppression.

Any PPPL facilities designated Occupancy Category IV would be assigned to SDC C.

- **Conclusion**

Based on Exemption b of RP-08 (Section 1.3), existing PPPL facilities do not require a 10-year natural phenomena hazard (NPH) assessment unless they meet the requirements of an Occupancy Category IV facility (i.e., by satisfying at least one of criteria 1-5 above). Any PPPL facility designated Occupancy Category IV would require a seismic evaluation (and possible retrofitting) if a project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 50 percent of the replacement value of the building.

Attachment B. USGS Design Map Summary using 2012/2015 IBC

Design Maps Summary Report

4/19/18, 11:18 AM

USGS Design Maps Summary Report

User-Specified Input

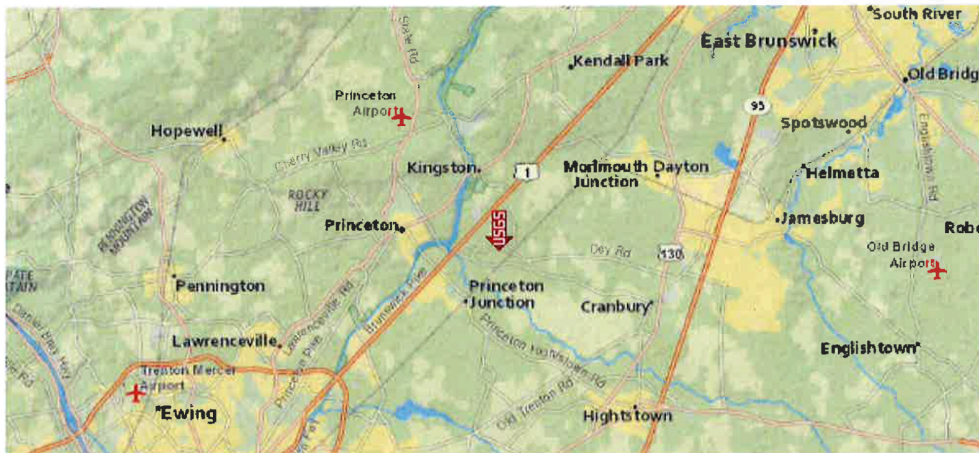
Report Title PPPL 2010 IBC 2012/15
Thu April 19, 2018 15:18:48 UTC

Building Code Reference Document 2012/2015 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 40.34844°N, 74.60258°W

Site Soil Classification Site Class C – “Very Dense Soil and Soft Rock”

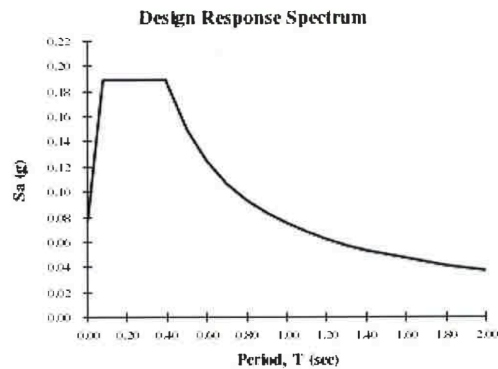
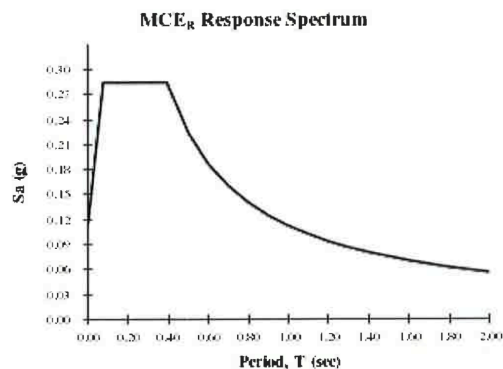
Risk Category I/II/III



USGS-Provided Output

$S_s = 0.237 \text{ g}$ $S_{MS} = 0.284 \text{ g}$ $S_{DS} = 0.189 \text{ g}$
 $S_1 = 0.066 \text{ g}$ $S_{M1} = 0.112 \text{ g}$ $S_{D1} = 0.075 \text{ g}$

For information on how the S_s and S_1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.



Attachment B USGS Design Map Summary using 2010 ASCE 7

Design Maps Summary Report

4/19/18, 11:17 AM

USGS Design Maps Summary Report

User-Specified Input

Report Title PPPL 2010 ASCE 7
Thu April 19, 2018 15:16:49 UTC

Building Code Reference Document ASCE 7-10 Standard
(which utilizes USGS hazard data available in 2008)

Site Coordinates 40.34844°N, 74.60258°W

Site Soil Classification Site Class C – “Very Dense Soil and Soft Rock”

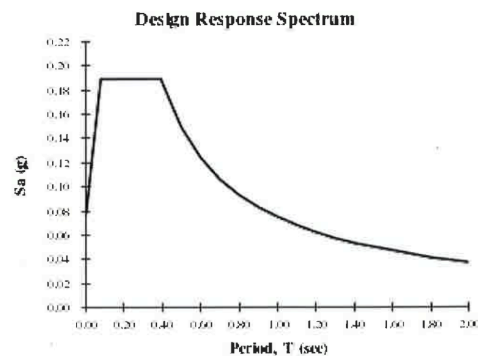
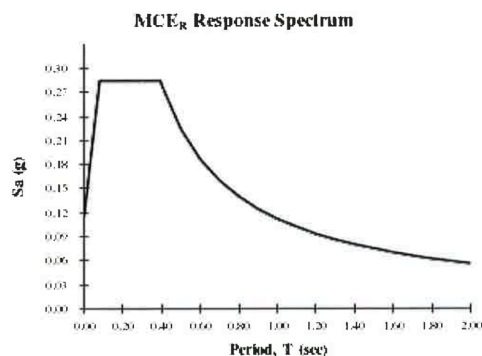
Risk Category I/II/III



USGS-Provided Output

$S_s = 0.237 \text{ g}$ $S_{MS} = 0.284 \text{ g}$ $S_{DS} = 0.189 \text{ g}$
 $S_1 = 0.066 \text{ g}$ $S_{M1} = 0.112 \text{ g}$ $S_{D1} = 0.075 \text{ g}$

For information on how the S_s and S_1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.



PPPL	PRINCETON PLASMA PHYSICS LABORATORY	ENGINEERING STANDARD	ES-MECH-019 Rev 0 Attachment C
General Requirements for PPPL as a DOE Facility			Page C-1 of C-2

Attachment C. General Requirements for PPPL as a DOE Facility

A. DOE order 420.1C (only pertinent paragraphs provided)

Chapter 4 NATURAL PHENOMENA HAZARDS MITIGATION

2. APPLICABILITY. Requirements in this chapter apply to all government-owned and government-leased nuclear and nonnuclear facilities and sites. Design requirements (Sections 3.a, 3.b, and 3.c, below) apply to new facilities, major modifications, and modifications that may be warranted based on periodic NPH assessment and upgrade requirements. Per Attachment A, Jerry Levine, Head ES&H, has concluded: “Based on Exemption b of RP-08 (Section 1.3), existing PPPL facilities do not require a 10-year natural phenomena hazard (NPH) assessment unless they meet the requirements of an Occupancy Category IV facility (i.e., by satisfying at least one of criteria 1-5 [see Section 8.1]). Any PPPL facility designated Occupancy Category IV would require a seismic evaluation (and possible retrofitting) if a project is planned that significantly extends the building’s useful life through alterations or deferred maintenance that total more than 50 percent of the replacement value of the building.” Such a project defines a “major modification.”

3. REQUIREMENTS

(b) NPH Design Criteria. All new facilities and major modifications must satisfy the applicable requirements and criteria contained in DOE-STD-1020-2012, Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities. (Note: Requirements for non-nuclear facilities are described in Section 2.1 of DOE-STD-1020-2012.).

B. DOE-STD-1020-2012 has been superseded by 2016:

(<https://www.standards.doe.gov/standards-documents/1000/1020-astd-2016>) and Section 2.2 on non-nuclear facilities applies to A-1 experimental facilities.

Section 2.1 All DOE facilities, nuclear and non-nuclear, are required to comply with Public Law 101-614, National Earthquake Hazards Reduction Program Reauthorization Act (as amended), and Executive Orders regarding seismic and flooding safety.

Section 2.2 NON-NUCLEAR FACILITIES

This Section applies to DOE facilities other than Hazard Category 1, 2, and 3 nuclear facilities. These facilities do not have nuclear material above DOE Hazard Category 3 thresholds (see DOE-STD-1027-92, Chg. 1, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports). PPPL has no Hazard Category 1, 2, or 3 nuclear facilities.

“2.2.1 Facilities Without Chemical or Toxicological Hazards: For facilities that do not have any chemical or toxicological hazards, categorization and design of Structure, System, or Component (SSC) subjected to NPH loads shall be performed using the criteria and guidelines given in Chapter 16 of IBC-2015.”

C. Chapter 16 of IBC-2015: <https://codes.iccsafe.org/public/document/code/542/9680723>

SECTION 1604.5 RISK CATEGORY

Each building or structure shall be assigned a risk category in accordance with Table 1604.5 based on the nature of occupancy. Buildings at PPPL fall into Risk Category II.

SECTION 1613 EARTHQUAKE LOADS

Every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 and Appendix 11A. The seismic design category for a structure is permitted to be determined in accordance with Section 1613 or ASCE 7.

D. ASCE 7 <http://www.asce.org/asce-7/> (MECH-019 Section- 8 above provides ASCE chapter breakdown.)

E. USGS website: <https://earthquake.usgs.gov/designmaps/us/application.php?>