DOE-STD-1020-2016, Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities

Sharon Jasim-Hanif, Ph.D.
Office of Nuclear Safety Basis & Facility Design (AU-31)

November 2017
Overview

Contents:

• NPH Program Summary
• DOE Standard 1020-2016
• DOE Handbook 1220-2017
NPH Program Summary

- **DOE Office:** Office of Nuclear Safety (AU-30)
- **Mission:** Develop & maintain requirements, standards and guidance for DOE facilities exposed to NPHs
- **Driver:** Established through DOE Order (O) 420.1C, Facility Safety
- **Direction & Guidance:** Seismic, extreme wind, tornado, precipitation, flood, volcanic & lightning hazards
- **How:** Provides assistance, training, communications & support to facilitate effective implementation of DOE’s NPH Requirements to assure public & worker health & safety
DOE Natural Phenomena Hazard (NPH) Requirements

DOE STANDARD
Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities

U.S. Department of Energy
Washington, D.C. 20585

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
DOE used the following to support implementation of the NPH requirements:

<table>
<thead>
<tr>
<th>Year</th>
<th>DOE Standards</th>
<th>Background Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td></td>
<td>UCRL-15910</td>
</tr>
<tr>
<td>1994</td>
<td>DOE STD-1020-94</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>DOE STD-1020 Change Notice #1</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>DOE STD-1020-2002</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>ASCE 43</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>DOE STD-1189-2008</td>
</tr>
<tr>
<td>2012</td>
<td>DOE STD-1020-2012</td>
<td>DOE STD-1189, ANS 2.26, ASCE 43</td>
</tr>
<tr>
<td>2016</td>
<td>DOE STD-1020-2016</td>
<td>DOE STD-3009-2014</td>
</tr>
</tbody>
</table>
DOE-STD-1020-2016
Revision Scope

• Summary of Technical Changes:
  – Corrected errors & omissions in DOE-STD-1020-2012 (Table 2-1)
  – Aligned with updated DOE-STD-3009-2014, DOE-STD-1189-2016, and DOE O 420.1C, Chg. 1 (Table A-1)
  – Implemented results from 10 Year NPH Assessment Review Report
  – Aligned with updated industry standards and voluntary consensus codes
  – Invoked updated Executive Order (EO) requirements

• Summary of General Changes:
  – Consolidated ‘shall’ statements from 400 to 140 requirements
  – Minimized rephrasing of requirements from industry standards
  – Improved clarity significantly
  – Overall length reduced from 90 to 55 pages
  – Reorganized sections to better emphasize DOE NPH requirements
Organization - NO change:

Section 1. Introduction
Section 2. General Criteria for NPH Design
Section 3. Seismic Design
Section 4. Wind, Tornado, and Hurricane Design
Section 5. Flood, Seiche, and Tsunami Design
Section 6. Lightning Design
Section 7. Precipitation Design
Section 8. Volcanic Eruption Design
Section 9. Evaluation and Modification of SSCs in Existing Facilities
Section 10. Quality Assurance and Peer Review
1.0 Introduction
Section 1

Purpose (1.1)
• Provide criteria and guidance for the NPH requirements of DOE O 420.1C, Chg. 1
• Ensure that SSCs will perform assigned safety functions during and after design basis NPH events; and
• Provide requirements and guidance in the use of building codes and voluntary consensus standards

Applicability and Scope (1.2)
• Government facilities
  – Owned and leased
• Nuclear and non-nuclear facilities
  – Nuclear, Hazard Category 1,2 and 3
  – Non-nuclear & radiological (HC<3)
• New and existing facilities
  – New construction
  – Major modifications of existing facilities
  – Modifications of existing facilities triggered by periodic NPH assessments
2.0 General Criteria for NPH Design
Overview

Non-Nuclear and < HC 3 Facilities
• 2.1 EO Compliance
• 2.2 Non-Nuclear Facilities

Nuclear, HC 1, 2 and 3 Facilities
• 2.1 EO Compliance
• 2.3 NPH Design Category
• 2.4 Limit States
• Sections 3-10

HC = Hazard Category per DOE-STD-1027
NPH Analysis & Design Overview

**Non-Nuclear Requirements**

**Step 1**
New Facility: Select Site

**Step 2**
Establish regulatory requirements for site

**Nuclear Hazard Category 1,2,3 Requirements**

**Step 3**
Safety Analyses (DSA)
To identify safety SSCs

**Step 4**
Common-cause failure & system interaction

**Step 5**
NPH categorization
Establish performance criteria

**Step 6**
Design/evaluate identified SSCs ensuring functionality
Section 2.1.1
PL 101-614 & EO 13717

  - Imposes seismic safety standards for preserving lives (i.e. Life Safety Limit State) of building occupants.
  - Applies to all federally owned, leased, financially assisted and regulated nuclear and non-nuclear facilities

- Requirements
  - New buildings comply with IBC-2015
  - Existing buildings comply with RP-8
    - Limited reevaluation triggers
    - Exempt buildings
    - Benchmark buildings
  - Any building meeting the requirements of STD 1020-2012 are in compliance
  - Many buildings meeting earlier versions of DOE-STD-1020 are in compliance
**Section 2.1.2**  
**EO 13690 and EO 11988**

- EO 11988
  - Flood risk management
  - Applies to both nuclear and non-nuclear facilities
- DOE-STD-1020-2016:
  - Flood design parameters conform to EO 11988, as amended by EO 13690
  - EO 13690 was REVOKED in August 2017
    - Reference to be removed from DOE-STD-1020 (see FAQ/ page change update)
  - Nuclear facilities have more stringent requirements

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amends EO 11988 500 year flood</td>
<td>Discourage building in flood planes 100 year flood</td>
</tr>
<tr>
<td>Lessons learned from Hurricane Sandy Consider climate change</td>
<td>Recommends flood proofing + other flood protection measures</td>
</tr>
</tbody>
</table>
Section 2.2
Non-Nuclear & <HC-3 Facilities

• Requirements:
  – IBC-2015 building design/practices for new buildings
  – EO 13717 Seismic Safety (ICSSC RP-8 for existing buildings)
  – NFPA-780-2017 for lightning protection
  – 29 CFR 1910.1200 for chemical/toxicological facilities
  – DOE-STD-1212-2012 for explosives
  – SSC NPH Design categorization - NOT required
  – 10 year NPH Assessment Review - NOT required
Section 2.3
Nuclear Facilities

Component Identification

- Safety SSCs identified in DSA
- Interaction effects (II/I evaluation) using ANS 2.26
- Prevent/Mitigate common-cause failures

NPH Design Category

- Determines magnitude of NPH load
- SSC categorizations (NDCs) using the Table 2-1 and limit states, as applicable

SSC NPH Design Categorization Process

Seismic
Section 3

Other NPHs
Sections 4 - 8
ANSI/ANS 2.26, *Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design*, is used for determining Seismic Design Category (SDC) and Limit State (LS) for SSCs subjected to seismic hazards.

DOE-STD-1020 uses ANS 2.26 methodology for determining other NPH events (e.g., Flood, Wind, Precipitation and Volcano) Design Categories (NDC), and Limit States.

ANS 2.26 provides guidance to map common safety functions to limit state.
- Confinement → LS-C
- II/I Collapse Prevention → LS-A
• Target Performance goal of SSC
  – SSC with low failure consequences have commercial performance goals
  – SSC with high consequences have better performance
• Return period of the design NPH event
• Determines the magnitude of NPH load
• Determines the structural capacity
• Graded Categories NDC-1 thru NDC-5
  – Based on unmitigated consequences of ‘failure’
    • ‘Failure’: SSC does not perform its safety function
    • Failure is determined by deformation
  – NDC-1: Low ‘failure’ consequences.
    • Commercial building
  – NDC-5: High 'failure' consequences.
    • Reactor containment
Table 2-1: Design Categories in NPH Event

<table>
<thead>
<tr>
<th>Category</th>
<th>Co-located Worker</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDC-1</td>
<td>&lt; 5 rem TED</td>
<td>Or ≥ PAC-1³</td>
</tr>
<tr>
<td>NDC-2</td>
<td>5 - 100 rem TED</td>
<td>5 - 25 rem TED</td>
</tr>
<tr>
<td>NDC-3</td>
<td>&gt; 100 rem TED</td>
<td>&gt; 25 rem TED</td>
</tr>
</tbody>
</table>

- Design categories determined from safety ‘hazard evaluation’ analysis per DOE-STD-3009-2014.
- Methodology determines unmitigated consequences of SSC failure for radiological and chemical releases to co-located workers & public
Section 2.4
Limit States

- Indicates the level of structural deformation
- Deformation is quantified by Limit States
  - LS-A: Short of collapse, stable
  - LS-B: Moderate permanent deformation
  - LS-C: Limited permanent deformation
  - LS-D: Essentially elastic
- Limit State is independent of NDC
- Limit State is independent of NPH event

- Common safety functions/sample failure modes
  - Equipment operability
  - Leak tightness (leaking pipe fittings)
  - Confinement compromised
  - Control room not habitable
  - Immediate occupancy
  - Life safety
  - Building collapse prevention
- Each of these failure modes can be linked to excessive deformation

Non-seismic Limit States
- For static loads, energy absorption can result in large deformations prior to failure but may not reduce the structural capacity required to resist the static loads:
  - Wind loads on buildings (except Tornado missiles)
  - Precipitation loads
  - Flood loads
  - Volcanic ash loads
- Design to code required strength using code load combinations and strength reduction factors

Seismic Limit States
- Energy absorption can reduce the structural capacity required to resist dynamic loads
  - Seismic ground motion
  - Impact from tornado missile
  - Blast loads
### Summary of Changes

#### Sections 3-5

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Seismic Design</td>
<td>Updated response modification coefficient values for SDC 1 &amp; 2 SSCs</td>
</tr>
<tr>
<td>4</td>
<td>Wind Design</td>
<td>Added guidance - wind generated missile assessment for extreme straight-line winds&lt;br&gt;Details transferred to NPH Handbook</td>
</tr>
<tr>
<td>5</td>
<td>Flood Design</td>
<td>Details transferred to NPH Handbook</td>
</tr>
<tr>
<td>6</td>
<td>Lightning Design</td>
<td>No significant change in requirements&lt;br&gt;Details transferred to NPH Handbook</td>
</tr>
<tr>
<td>7</td>
<td>Precipitation Design</td>
<td>Clarified sites between 100 and 400km from a Quaternary volcanic vent shall use&lt;br&gt;a graded approach for a volcanic hazard assessment. &lt;br&gt;Return Periods for Volcanic Ashfall Structural/Non-Structural provided</td>
</tr>
<tr>
<td>8</td>
<td>Volcanic Eruption Design</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Topic</td>
<td>Change</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 9.2.1   | Periodic Review & Update of NPH Assessments    | CLARIFIED: Which Facilities: DOE nuclear facilities with safety SSCs classified as NDC-3 +  
|         |                                                | When: Every 10 years & whenever significant changes in NPH data, models, or analysis methods have been identified.  
|         |                                                | How: Follow criteria in DOE-STD-1020  
|         |                                                | No Update Needed: Justify & document decision |
| 9.2.1.1 | Schedule guidelines for 10 YR NPH assessment review | NEW: Added guidance on aging “beyond planned design lifetime” facilities. Evaluate for aging-related degradation and their ability to continue to perform their safety function. |
| 9.3.8   | Facility Condition Assessment                  | NEW: Added guidance on aging “beyond planned design lifetime” facilities. Evaluate for aging-related degradation and their ability to continue to perform their safety function. |
# Summary of Changes

## Section 10

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Quality Assurance &amp; Peer Review</td>
<td>NEW: Software Quality Assurance (SQA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NEW: section 10.3 Use of Experts and Peer Review for Site Characterization</td>
</tr>
</tbody>
</table>
DOE Handbook 1220-2017

DOE-STD-1020 commentary/guidance/good practices

- DOE-STD-1020-2012 and DOE-STD-1020-2016 streamlined to focus the NPH Standard on requirements.
- DOE-STD-1020-2002 and prior revisions addressed the evolution of and technical basis for DOE’s unique NPH requirements as well as explanatory material.
- The Handbook does not include any requirements and is not invoked by any DOE Directive or Rule.
- It provides a compilation of good practices, lessons-learned, technical bases and technical insights, practical examples and applications based on DOE and nuclear industry experience.
Contacts

• Sharon Jasim-Hanif, DOE-STD-1020-2016 Lead, Office of Nuclear Safety Basis and Facility Design (AU-31)
  Phone: 301/903-4664;
  E-mail: sharon.jasim-hanif@hq.doe.gov

• Pranab Guha, Acting Director, (AU-31)
  Phone: 301/903-7089;
  E-mail: pranab.guha@hq.doe.gov

http://www.energy.gov/ehss/natural-phenomena-hazards-program