Summary of New DOE-STD-1020-2011 NPH Analysis and Design Criteria for DOE Facilities (Proposed)

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Purpose of Revising the current version of DOE-STD-1020

- To conform to the new DOE O 420.1C (in review) that no longer refers to the Natural Phenomena Hazards (NPH) guidance document, DOE G 420.1-2
- To provide a single/central guidance document that the new DOE O 420.1C can require for NPH analysis and design criteria
- To put back analysis and design requirements for all major NPHs in a single document that were fragmented when, with the issuance of STD-1189-2008, the seismic provisions of STD-1020, STD-1021, STD-1022, STD-1023 were superseded by new documents, but not the wind and flood provisions.
- To update STD-1020 by incorporating the recently-developed voluntary consensus NPH-related standards (e.g., ANS 2.26-2004, ANS 2.27-2008, ANS 2.29-2008, ANS 2.3-2011, ASCE 43-05) and cross-connecting these with STD-1189 and this revised version of STD-1020
- To add analysis and design criteria for a few more NPHs

SSC design categorization criteria & methodology for seismic hazards in ANS 2.26 and STD-1189 are now used for all NPHs

For nuclear facilities, NPH design category is determined based on collocated worker OR public dose (unmitigated) resulting from SSC failure in accordance with ANS 2.26 methodology and STD-1189 criteria:

- **5 Seismic Design Categories, SDC-1 through -5**
- **5 Wind Design Categories, WDC-1 through -5**
- **5 Flood Design Categories, FDC-1 through -5**
- **5 Precipitation Design Categories, PDC-1 through -5**
- **5 Volcanic Design Categories, VDC-1 through -5**

Dose based design categorization is not used for lightning hazards

SSC failure and resulting dose consequences are determined by performing hazard evaluation using methodology given in STD-3009 and STD-1189.

SSC design categorization criteria in STD-1020-2011 (cont'd)

- **Uses Table 1.5-1 of ASCE 7-10 for non-nuclear hazardous and non-hazardous facility categorization.**
- **Uses Appendix B of STD-1189 and Table A.3 of ANS 2.26 for categorizing nuclear facilities with chemical hazards.**
- **Design basis NPH return period and the rigor with which an SSC is analyzed & designed are selected based on NPH design category of the SSC.**

SSC failure is defined as its failure to perform it's design basis safety function(s)

- However, even if an SSC (say, SSC "A") does not have any design basis safety function (active or passive) by itself, but it's failure can cause the failure of safety function of another SSC (say, SSC "B"), the NPH design category of SSC "A" shall be at least the same as that of SSC "B." Note: it is possible that the deformation or stress level at which SSC "A" failure may adversely affect the safety function of SSC "B," can be more or less than that at which SSC "B" fails to perform it's safety function.
- All possible modes of SSC failure are to be considered; two primary modes considered are: deformation (or stress) related, and water intrusion related.
- Consideration of common-cause failures and cascading effects have been empasized.

SSC failure considerations (cont'd)

- SDC-3, -4, and -5 building structural components having direct safety or confinement functions are not permitted to be designed to Limit States A or B.
- An SSC whose deformation may DIRECTLY lead to a credible nuclear criticality accident potential must be designed to remain elastic. Such an SSC must also be designed at least to NPH design category 3.
- To ensure development of proper SSC failure criteria, the following professionals should work together:
  - A Safety Analyst for hazard & accident analyses
  - An NPH Design Engineer
  - An Equipment Expert or the Cognizant System Engineer

STD-1020-2011 retains the current seismic analysis and design criteria, with some state-of-the-art modifications

For SDC-3, -4, and -5 SSCs, uses:

- **ANS 2.26, for categorization methodology and Limit State selection**
- **ANS 2.27, for seismic site characterization**
- **ANS 2.29, for probabilistic seismic hazard assessment (PSHA) & site response analyses (Use of CAV filtering is restricted)**
- **ASCE 43, for site response analyses, determination of design response spectra, inelastic energy absorption factors, and seismic design criteria**
- **ASCE 4, for seismic analyses and determining seismic demand (Use of wave incoherence provision is not permitted)**
- **NRC Reg. Guide 1.208 and NUREG/CR 6728, for integrating site response into PSHA**

For SDC-1 and SDC-2 SSCs, STD-1020-2011 uses seismic analysis and design provisions of ASCE 7-10

- **SDC-1 SSCs with Limit State A as failure definition are considered equivalent to Risk Category II (RC-II) of ASCE 7-10.**
- **SDC-2 SSCs with Limit State B as failure definition are considered equivalent to Risk Category IV (RC-IV) of ASCE 7-10.**
- **For SDC-1 and SDC-2 SSCs with other Limit States, new response modification coefficients are given by updating those given in Appendix A of STD-1189-2008**

Extreme straight-line wind, tornado, and hurricane design criteria of STD-1020-2011 are somewhat different from current criteria

For WDC-3, -4, and -5 SSCs, the new standard:

- **Requires either site-specific probabilistic wind hazard analyses (PWHA) OR the use of ANS 2.3-2011 provisions.**
- **Requires consideration of both structural and water-intrusion modes of failure.**
- **Requires wind or missile barriers to be assigned to a WDC equal to (or higher) the category of the SSC to be protected.**
- **Requires barrier deformation limits to be consistent with it's safety function**

Return periods for extreme straight-line wind, tornado, and hurricane are somewhat different from those before, but more conservative

WDC	Design Basis Mean Return Period in Years		
	Extreme St.-Line Wind	Hurricane Wind	Tornado Wind
WDC-3	**2500** (was 1000, increased for consistency with SDC-3)	**2500** (was 1000, increased for consistency with SDC-3)	**50,000** (same as before)
WDC-4	**5000**	**5000**	**125,000**
WDC-5	**10,000** (same as before for PC-4)	**10,000,000** (NRC requirement for commercial NPP)	**10, 000,000** (NRC requirement for commercial NPP)

Criteria & guidelines for flood hazards in STD-1020-2011 are not much different from those currently used

- **Flood design category (FDC) of an SSC must be based on the unmitigated consequences of failure resulting from all flood & hydrology-related hazards.**
- **A design basis flood level (DBFL) must be determined based on a probabilistic flood hazard analysis (PFHA)**
- **All failure modes, including those from deformation (say, due to added hydrostatic & hydrodynamic water pressure), water intrusion, and submergence must be considered.**
- **Design basis return periods for SSCs are selected with the objective of achieving a probabilistic target performance goal for SSCs that may fail due to deformation equal to those that may fail unconditionally due to water intrusion and submergence.**

All SSCs that may fail unconditionally due to water intrusion or submergence must be placed above the DBFL

- **But, if such SSCs cannot be placed above the DBFL from cost or other practical considerations, these must be protected by engineered features designed to prevent water intrusion & submergence resulting from a DBFL that corresponds to an FDC equal to or higher than that for the SSC being protected.**
- **Design basis return periods for such SSCs are:**

SSC Category	FDC-1	FDC-2	FDC-3	FDC-4	FDC-5
Return Period (Years)	500 (Same as PC-1)	2000 (Same as PC-2)	10,000 (Same as PC-3)	25,000	100,000 (Same as PC-4)

STD-1020-2011 provides new criteria for SSCs that may fail due to deformation from flood-related structural loads

- **Design basis return periods for such SSCs are:**

SSC Category	FDC-1	FDC-2	FDC-3	FDC-4	FDC-5
Return Period (Years)	Same as those in ASCE 7-10		2500 (Same as SDC-3)	5,000	10,000 (Same as SDC-5)

Determination of DBFL for various FDCs

For sites with FDC-3, -4, OR -5 as the highest FDC:

- **Perform a flood screening analysis (FSA) to determine if a comprehensive flood hazard assessment is necessary and if the site can be considered a flood-dry site**
- **Based on FSA results, if necessary, perform a PFHA to determine the DBFL based on the applicable return period for the highest FDC SSCs in the facility or the site.**

For sites with FDC-1 OR -2 as the highest FDC, DBFL shall be either based on STD-1020-2011 or on IBC and ASCE 7-10. However, if DBFL is based on STD-1020-2011, it must not be lower that that obtained from the application of IBC and ASCE 7-10 provisions.

STD-1020-2011 provides only top-level criteria & guidelines for lightning design

- **While performing systematic facility safety and hazard evaluation using STD-3009 and STD-1189 requirements, SSCs that would need lightning protection to ensure their safety function are required to be identified.**
- **These SSCs are required to be designed such that these are protected in accordance with NFPA 780-2011, *Standard for the Installation of Lightning Protection Systems.***
- **Lightning protection systems are required to be installed and maintained in accordance with NFPA 780-2011.**
- **Also, when a Faraday Shield is employed, the lightning protection systems are required to be installed and maintained in accordance with DOE Standard 1212, *Explosives Safety.***

STD-1020-2011 separates out the criteria & guidelines for precipitation (rainfall, snow, and ice) design

Criteria & guidelines provided include those for:

- **Determination of precipitation design category (PDC)**
- **Site precipitation characterization including characterizing the hydrological and meteorological data**
- **Determination of precipitation design parameters**
- **Probabilistic Precipitation Hazard Assessment (PPHA)**
- **Designing SSCs to mitigate precipitation hazards**

SSC categorization, site characterization, & precipitation design parameters

- Precipitation design category (PDC) are determined based on the same criteria as other hazards.
- Failure of SSCs due to deformation as well as due to water intrusion resulting from precipitation are considered.
- Site characterization is performed to obtain the data necessary to perform a site-specific PPHA.
- The degree of rigor with which precipitation, hydrologic, and meteorological characteristics are investigated commensurate with the highest PDC.
- Two types of precipitation-related hazards are considered: (i) water intrusion or submergence due to local site/facility flooding, and (ii) structural damage due to added loads (e.g. roof damage from ponding)

PPHA and design basis return periods for determining design basis precipitation level (DBPL)

- **For sites with only PDC-1 and -2 SSCs, DBPL must be determined based on ASCE 7-10 requirements.**

For sites with PDC-3, -4, or -5 SSCs:

- **the DBPL must be determined based on a site-specific PPHA**
- **To preclude SSC failure due to water intrusion or submergence, return periods for determining DBPL shall be :**

SSC Category	PDC-3	PDC-4	PDC-5
Return Period (Years)	10,000 (Same as FDC-3)	25,000 (Same as FDC-4)	100,000 (Same as FDC-5)

Design basis return periods for determining DBPL associated with precipitation-related structural loads

For sites with PDC-3, -4, or -5 SSCs, return periods for determining DBPL associated with precipitation-related structural loads shall be :

SSC Category	PDC-3	PDC-4	PDC-5
Return Period (Years)	2500 (Same as SDC-3)	5,000	10,000 (Same as SDC-5)

Designing SSCs for precipitation loads

- **PDC-1 & PDC-2 SSCs shall be designed using criteria given in ASCE 7-10 for Risk Category II and Risk category IV, respectively**
- **PDC-3, PDC-4, & PDC-5 SSCs shall be designed based on site-specific PPHA using the specified return periods and load combinations in this standard, and methodology given In ASCE 7-10**

STD-1020-2011 provides new criteria and guidelines for volcanic eruption design, somewhat similar to seismic design

- **The primary volcanic hazard for which criteria and guidelines are provided is volcanic ashfall causing additional structural loads and adversely affecting safety-related ventilation systems.**
- **Designing for localized hazards such as lava flows, ballistic projectiles, pyroclastic flows, mud flows, etc. are not considered practical; such hazards should be mitigated by locating the facility at appropriate distance from potentially active volcanoes.**
- **Applicable to DOE sites within 400 km of a volcano that erupted within the Quatenary Period (2.6 m years) & for facilities envisioned life spans up to 100 years**
- **Volcanic design categories (VDCs) and target performance goals (TPGs) are determined the same way as SDCs.**
- **Guidelines are provided for site characterization.**

Other design considerations for volcanic hazards

- **Ash loads if considered applicable from site characterization, are required to be determined by performing a probabilistic site-specific volcanic eruption hazard analysis.**
- **Return periods for determining ashfall loads are based on seismic TPGs given in ASCE 43-05, and Risk Reduction Factors (RRFs) consistent with the rigor and inherent conservatism in the design acceptance criteria and analysis methods used.**

STD-1020-2011 guidelines on evaluation & modification of existing facilities are very similar to those currently used

- At a frequency not to exceed 10 years, NPH data, data collection methods, NPH modeling techniques, and NPH evaluation methods, used in the current facility design, are required to be reviewed for "significant" changes.
- "Significant" changes relate to those affecting the major inputs to hazard calculations and impacting the current site design standards.
- Even if the changes in the hazard results are not expected to be "significant," large changes to the input parameters may warrant a new hazard assessment.
- A decision on updating an NPH assessment should consider:
  - Number of facilities affected and the hazard level posed;
  - Lifecycle stages of the facilities affected;
  - whether the assessment results will be used as design input for future facilities

Modification of Existing Facilities

- **Existing facilities not undergoing modifications for programmatic reasons need not apply the NPH design categorization criteria of this standard in a backfitting sense.**
- **Design of major modifications must conform to this standard**
- **Strengthening of existing SSCs that do not meet the provisions of this standard and which cannot be easily remedied shall be undertaken on a prioritized basis using a cost versus risk-reduction analysis.**
- **For facilities with a remaining life of 5 yrs or less, it is permissible to use half the return period, but not to reduce the demand by more than 20%.**
- **Additional hazard-specific guidelines for evaluating existing facilities have been provided for seismic, wind, and flood hazards.**