INTEGRATION OF SAFETY INTO SEISMIC DESIGN PROCESS THROUGH ANS 2.26, ASCE 43 & DOE-STD-1189

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Appendix A.1 of STD-1189 Conditionally Adopts ANS 2.26 & ASCE 43

- Appendix A.1 of STD-1189, through DOE Interim Guidance (IG) for Natural Phenomenon Hazards (NPH), provides guidance for integration of safety into the seismic design process

- For seismic design, the IG & STD-1189 conditionally replace STD-1021 & STD-1020 with ANS 2.26 & ASCE 43, respectively

- Major seismic provisions of ANS 2.26 and STD-1189 are presented here

ANS 2.26 Provides Guidelines and Requirements for Seismic Categorization

- To achieve increased optimization & flexibility, ANS 2.26 introduces a seismic design process that is based on two parameters (STD-1021 uses one):
  - Unmitigated failure consequences of the SSC being categorized. This determines the Seismic Design Category (SDC)
  - Limit State, defined by the minimum level of deformation, displacement, or stress at which the SSC is considered to fail to perform its safety function
- SDC & Limit State establishes the Seismic Design Basis (SDB)

ANS 2.26 Provides Criteria for 5 Seismic Design Categories and 4 Limit States

- 5 SDCs are defined based on qualitative (mandatory) and quantitative (non-mandatory) criteria for adverse consequence to workers, public, and the environment: SDC-1 (least severe) through SDC-5 (most severe)
- Permissible seismic damages for 4 Limit States are:
  - A: Large permanent distortion & leakage
  - B: Moderate permanent distortion & minor leakage
  - C: Minor permanent distortion so as to retain confinement function & preclude need for repair
  - D: No permanent distortion so as to maintain elastic behavior, containment function, and preclude inadvertent nuclear criticality

Unlike STD-1021, ANS 2.26 Permits Use of Any Limit State for Any SDC

- Except for “two-over-one” situations, STD-1021 essentially specifies Limit State A for PC-1, B for PC-2, C for PC-3, and D for PC-4
- ANS 2.26 uses a Limit State that is consistent with the SSC safety function; thus, depending on the safety function, an SDC-4 SSC can be designed to Limit State A if the SSC can perform its safety function even when it has large permanent distortion
- Also, an SDC-2 SSC can be designed to Limit State D (e.g., a Safety Significant fan or pump shaft that must remain functional during and after a design basis earthquake) [Appendix B of ANS 2.26 provides guidance on the selection of Limit States]

Other Major Guidelines in ANS 2.26

- For designing SDC-3, SDC-4, and SDC-5 SSCs:
  - Use ANS 2.27 guidelines for site-specific geotechnical investigation
  - ANS 2.29 and probabilistic seismic hazard analysis (PSHA)
  - ASCE 43 for seismic design criteria and analysis methods
- For SDC-1, Limit States A, B, and C, use provisions of IBC applicable for Seismic Use Groups I, II, and III, respectively

Other Major Guidelines in ANS 2.26 (cont'd)

- For SDC-2, Limit States A and B, use provisions of IBC applicable for Seismic Use Groups II, and III, respectively
- Use Probabilistic Target Performance Goals for:
  - SDC-3: 10^{-4}/year [same as that for PC-3]
  - SDC-4: 4×10^{-5}/year
  - SDC-5: 10^{-5}/year [same as that for PC-4]
- Use ANS 2.29 & ASCE 43 and select Uniform Hazard Response Spectrum at a mean frequency of:
  - 4×10^{-4}/year for SDC-3 [same as that for PC-3]
  - 4×10^{-4}/year for SDC-4
  - 10^{-4}/year for SDC-5 [same as that for PC-4]

Other Major Guidelines in ANS 2.26 (cont'd)

- Seismic categorization shall be based on an unmitigated consequence analysis based on five concepts:
  - Defense-in-depth
  - Redundancy
  - Common-Cause Failure
  - System Interaction
  - Robustness
- If an SSC is at least one SDC higher than the SSC being categorized, it can be credited in the unmitigated consequence analysis of the SSC being categorized

Major Differences Between STD-1189 & ANS 2.26 Provisions

- STD-1189 dose criteria table is different and truncated from that in ANS 2.26, covering only SDC-1 thru SDC-3
- STD-1189 provides dose criteria for collocated workers
- SDC-2 dose limit is 25 rem in STD-1189, but only 5 rem in ANS 2.26
- SDC-3 dose limit is >25 rem in STD-1189, but 25 rem in ANS 2.26
- STD-1189 explicitly requires conservative bases for the unmitigated consequence analysis
- Recommends at least Limit State C or D for SSCs with confinement and leak tightness functions

STD-1189 Design Criteria for SDC-1 and SDC-2 SSCs with Limit States A, B, C, or D

SDC	Limit State A	Limit State B	Limit State C	Limit State D
1	ASCE 7-05 Occ. Cat I or II (I=1.0) $R_a = R$	ASCE 7-05 Occ. Cat I or II (I=1.0) $R_a = 0.8R$, But $R_a \geq 1.0$	ASCE 7-05 Occ. Cat I or II (I=1.0) $R_a = 0.67R$ But $R_a \geq 1.0$	ASCE 7-05 Occ. Cat I or II (I=1.0) Use $R_a = 1.0$
2	ASCE 7-05 Occ. Cat III or IV(1) $R_a = R$	ASCE 7-05 Occ. Cat III or IV(1) $R_a = 0.8R$, But $R_a \geq 1.0$	ASCE 7-05 Occ. Cat III or IV(1) $R_a = 0.67R$ But $R_a \geq 1.0$	ASCE 7-05 Occ. Cat III or IV(1) Use $R_a = 1.0$

STD-1189 Design Criteria for SDC-1 and SDC-2 SSCs with Limit States A, B, C, or D (cont'd)

- In the previous table:
  - I = Importance Factor
  - R = Response Modification Factor
  - R = Actual or reduced Response Modification Factor
- Note (1) in the table: STD-1189 requires that Occupancy Category IV be used if there is a radiological release consequence