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Natural Phenomena Hazards Assessment Criteria for DOE Sites: DOE Standard DOE-STD-1023-95

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NATURAL PHENOMENA HAZARDS ASSESSMENT CRITERIA FOR DOE SITES: DOE STANDARD DOE-STD-1023-95

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ABSTRACT

This paper summarizes hazard assessment criteria (DOE-STD-1023-95) for Natural Phenomena Hazards (NPH) at DOE sites. The DOE has established policy and requirements for NPH mitigation for DOE sites and facilities using a graded approach by DOE Order 5480.28. The graded approach is implemented by five performance categories established for structures, systems, and components (SSCs) at DOE facilities based on criteria provided by DOE-STD-1021-93. In applying the design/evaluation criteria of DOE-STD-1020-94 for DOE facilities subjected to one of the natural phenomena hazards, the establishment of design basis load levels consistent with the corresponding performance category is required. This standard provides general criteria as well as specific criteria for natural phenomena hazard assessments to ensure that adequate design basis load levels are established for design and/or evaluation of DOE facilities.

1. INTRODUCTION

It is the policy of the Department of Energy (DOE) to design, construct, and operate DOE facilities so that workers, the general public, and the environment are protected from the impacts of natural phenomena hazards (NPHs). This policy and the related requirements for natural phenomena hazard (NPH) mitigation are established by DOE Order 5480.28 (USDOE, 1993a). While general requirements are established by DOE 5480.28, specific criteria for the implementation of DOE 5480.28 requirements are defined by a set of DOE Standards.

DOE 5480.28 requires that structures, systems, and components (SSCs) at DOE facilities are designed and constructed to withstand the effects of natural phenomena hazards using a graded approach. The graded approach is implemented by the five (5) performance categories established for SSCs based on criteria provided by DOE-STD-1021-93 (USDOE, 1993b). The performance categories range from PC-1, which represents protection for life-safety at the level provided by model building codes, to PC-4, which represents protection from release of hazardous material similar to that provided by commercial nuclear power plants. Each performance category is assigned a performance goal with a mean annual probability of exceedance of acceptable behavior limits. The performance goals is a measure of the level of NPH protection and is used as a target for the establishment of NPH mitigation requirements. For each performance category, NPH design, evaluation, and construction requirements of varying conservatism and rigor are provided in DOE-STD-1020-94 (USDOE, 1994a).

In applying the design/evaluation criteria of DOE-STD-1020-94 for DOE facilities subjected to one of the natural phenomena hazards, the establishment of design basis load levels consistent with the corresponding performance category is required.

The purpose of this standard, DOE-STD-1023-95, is to provide criteria for natural phenomena hazard assessments to ensure that adequate design basis load levels are established for design and/or evaluation of DOE facilities. This Standard provides general criteria for natural phenomena hazard assessment as well as specific criteria applicable to various natural phenomena hazards including seismic, wind and tornado, and flood.

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2. GENERAL CRITERIA

Structures, systems, and components (SSCs) shall be designed and constructed to withstand the effects of natural phenomena hazards using a graded approach. In order to implement a graded approach, SSCs are placed into performance categories. The mean NPH hazard curve shall be used to determine the design basis NPH event for the design and/or evaluation of DOE SSCs.

For sites containing facilities with SSCs in Performance Category 3 or 4, a site specific probabilistic natural phenomena hazards assessment shall be conducted if none has been conducted within the last 10 years. This NPH assessment shall consider site-specific information as discussed in DOE-STD-1022-94 (USDOE, 1994b).

For sites containing facilities with SSCs in only Performance Category 1 or 2 and having no site-specific probabilistic NPH assessment, it is sufficient to utilize natural phenomena hazard maps from model building codes or national consensus standards. For sites which have site-specific probabilistic NPH assessments, the SSCs in Category 1 or 2 shall be evaluated or designed for the greater of the site specific values or the model code values unless lower site specific values can be justified and approved.

Specific criteria for seismic hazard assessment are provided in Section 3. Specific criteria for wind hazard assessment associated with wind, hurricane, and tornado are provided in Section 4. Specific criteria for flood hazard assessment are provided in Section 5.

Criteria for natural phenomena hazard assessments applicable to other natural phenomena hazards such as volcanic ash, lightning, and snow are not provided in this Standard. Where local or national codes and standards for other natural phenomena hazards do not provide the level of protection required by DOE-5480.28, separate hazard assessments should be conducted. If needed for these hazards, the assessments should be completed by the site and submitted to the cognizant DOE office.

3. DETAILED CRITERIA FOR SEISMIC HAZARD ASSESSMENT

3.1 GENERAL - In accordance with DOE-STD-1020-94, Design/Evaluation Basis Earthquake (DBE) spectra shall be determined and used for the design/evaluation process. The DBE spectra shall be a site-specific, median shape, anchored to the appropriate ground motion parameters scaled to the site mean probabilistic seismic hazard curve (SHC). When a site-specific response spectrum shape is unavailable, a median standardized spectrum shape, such as defined in NUREG/CR-0098 (Newmark and Hall, 1978) is acceptable.

This Standard provides criteria for conducting a probabilistic seismic hazard assessment (PSHA) in order to produce the seismic hazard curve for determining ground motion parameters for the DBE. It also provides criteria for determining the acceptable design response spectral shape.

The seismic hazard assessment shall consider all effects of earthquakes including not only earthquake ground shaking, but also earthquake induced ground failure modes such as fault offset, liquefaction, slope instability, lateral spreading, and subsidence.

For sites containing facilities with SSCs in only Performance Category (PC) 1 or 2, it is sufficient to utilize seismic hazard maps from the current version of model building codes or national consensus standards if no site-specific PSHA has been conducted for the sites. In lieu of more specific date, (i.e. if seismic hazard maps are not available for the specified annual probability of exceedance), the PC-2 DBE may be taken as 1.5 times the PC-1 DBE, except for sites near tectonic plate boundaries where the PC-2 DBE may be taken as 1.25 times the PC-1 DBE. These factors are based on average hazard curve slopes. For sites which have site-specific probabilistic seismic hazard assessments, the SSCs in Performance Category 1 or 2 shall be evaluated or designed for the greater of the site specific values or the model code values unless lower site specific values can be justified and approved by DOE.

For sites containing facilities with SSCs in Performance Category 3 or 4, a site-specific probabilistic seismic hazard assessment (PSHA) shall be conducted to determine the DBE.

3.2 Development of Site-Specific Seismic Hazard Curves - Two options are acceptable for the development of seismic hazard curves. The first option is to utilize existing probabilistic seismic hazard assessment (PSHA) studies. The second option is to conduct a new site-specific PSHA.

Any new site-specific hazard assessment to generate seismic hazard curves shall consider available site-specific geologic and seismic data base in conformance with DOE-STD-1022-94 (USDOE, 1994b).

3.2.1 Development of Seismic Hazard Curves Based on Existing PSHA. - This option allows the use of existing PSHA studies similar to those conducted by the Electric Power Research Institute (EPRI), 1989a) for the commercial nuclear power industry and Lawrence Livermore National Laboratory (LLNL) (Bernreuter, et al., 1989 and Savy, 1992 and 1993) for the U.S. Nuclear Regulatory Commission (USNRC), which can be used at particular DOE sites in the Eastern United States. Experience to date has shown that application of the 1989 LLNL and EPRI methodologies can yield significantly different results. Guidance for resolving the differences between the two 1989 studies is provided in DOE-STD-1024-92 (USDOE, 1992).

This option is particularly suitable for DOE sites in the eastern United States with the exception of sites located near active sources for large magnitude earthquakes, e.g., near New Madrid, Missouri and Charleston, South Carolina. In these cases, it is required to either incorporate additional site-specific seismic sources or show that the regional seismic sources in the LLNL or EPRI studies adequately model the tectonics in the vicinity of the site. See section 5.0 of DOE-STD-1024-92 for additional guidance.

3.2.2 Development of Seismic Hazard Curves Based on New Site-Specific PSHA - Acceptable methodologies for conducting new PSHA for DOE sites include, but are not limited to those used by Bernreuter, et al. (1989), EPRI (1989a), and Savy (1992 and 1993). An acceptable methodology for the development of DOE site specific seismic hazard curves must accommodate uncertainties in the potential earthquake occurrence and ground motion attenuation processes affecting the site.

The description given here applies to facilities with SSCs in Performance Category 4. For Performance Category 3, the same methodology as for Performance Category 4 is required but simplifications as described in Section 3.2.2.1 are acceptable. For lower categories (1 and 2), using these methodologies would not be required as stated in Section 3.1.

The following four elements shall be included in the methodology to conduct a new PSHA.

(1) Basic Hazard Model - Sec. 5.1.2.2.1 of DOE-STD-1023-95 provides detail discussion of this element.

At a given site, the hazard function SH(g) is defined by the probability $P(G \geq g)$ that the ground motion parameter G, e.g., the PGA or the pseudo response spectral velocity (PSV), exceeds some value g in t years for all earthquakes greater than a value M_o contributing to the hazard, i.e.,

$$SH(g) = P\,(G \geq g, \text{ for } m \geq M_o)$$

For well-engineered structures (built to modern seismic standards) such as commercial nuclear power plants, a lower bound magnitude (M_o) of 5 shall be used (EPRI, 1989b). For those DOE facilities which cannot be classified as built to modern seismic standards, such is not necessarily the case and the analyst should provide estimates of the hazard for M_o = 5 and M_o = 4.6, consistent with the lower bound used for national seismic hazard maps.

The hazard model is developed by examining characteristics of seismic sources and their contribution to the seismic hazard of the site (Cornell 1968). For a detailed description to the seismic of the acceptable methodologies, see Bernreuter (1989), EPRI (1989a) and Savy (1992, 1993).

The standard steps in the methodologies employed by a probabilistic seismic hazard analysis are summarized as follows:

Step 1: A zonation map, (with possibly additional information on the spatial distribution of earthquakes in any given zone). The zonation is a partition of the entire area of interest into independent zones. Each zone is assumed to be a unique source of earthquakes and to have its own recurrence distribution.

Step 2: The occurrence (frequency - magnitude distribution) is defined for each zone. This step quantifies the total number of earthquakes greater than magnitude M_O expected to occur during the period of interest (usually one year), and it describes the relative frequency of all the magnitudes greater than M_O. An upper bound (maximum) magnitude is defined for each recurrence distribution.

Step 3: The ground motion model provides the probability that g is exceeded at the site when an earthquake of magnitude m has occurred at a given location. Usually, the direction of the origin of the earthquake is neglected and only the distance to the site is considered in the ground motion modeling.

For a site where the ground motion model is not specifically applicable to the local geology, a site response evaluation should be performed and site corrections should be applied. The site response evaluation should consider field investigations, sampling and testing as described in DOE-STD-1022-94. Depending on the methods of analysis, the site correction is applied directly on the ground motion model or on the resulting hazard curve. Both methods are acceptable.

Step 4: Calculating the hazard curve by integrating the effects of all possible earthquake locations and all possible earthquakes with magnitudes greater than M_O occurring within each zone and all zones.

(2) Role of Data - Data used in the hazard modeling exists in various degrees of quantity and quality. Sec. 5.1.2.2.2 of DOE-STD-1023-95 provides further detail discussions.

A wide range of earth sciences (geologic, geophysical, and seismologic) data are considered when conducting a seismic hazard analysis. DOE-STD-1022-94 (USDOE, 1994b) discussed the manner in which these types of data are used to characterize seismic sources and to evaluate ground motions. The extent to which particular data sets have been gathered in the site region and immediate site vicinity will have a direct impact on the uncertainties in the seismic hazard analysis. In cases where significant uncertainties exist regarding seismic sources or site-specific conditions important to ground motions, additional data may need to be gathered to reduce uncertainties in the site-specific seismic hazard analysis.

Because the development of the basic inputs to seismic hazard analysis requires interpretations of data to develop models and parameter values, there is commonly a considerable range of possible interpretations for any particular data set. For example, for a site in the eastern United States, experts will make variable use of available geophysical data, tectonic information, and historical seismicity data to define the configurations of seismic source zones. Likewise, the available data pertinent to earthquake recurrence rates and maximum magnitudes for the seismic sources will likely allow a range of permissible interpretations.

Seismic Hazard analysts should take great care that the models and parameters are consistent with the data, which include all physical information (geophysical, geological, and geotechnical data, etc.) and historical date (earthquake catalogs). Models and hypotheses seemingly in disagreement with data (for example, a recurrence model that predicts recurrence rates several times higher than the empirical data) should be explained. All models and information provided should be thoroughly documented so that an independent party could review the study and understand the manner in which the data have been used to support the seismic hazard interpretations.

(3) Uncertainty in Hazard - Sec. 5.1.2.2.3 of DOE-STD-1023-95 provides detail discussions. Probabilistic seismic hazard analysis incorporates the random variability in the location, size, and ground motions associated with future earthquakes. In addition to this random variability, there is also a component of uncertainty related to lack of knowledge of the models and parameters that characterize the seismic hazard. For example, alternative seismic source maps could be developed, uncertainties in recurrence parameters can be quantified, and alternative ground motion attenuation relationships can be identified. These uncertainties result in a distribution of seismic hazard curves, from which the median (50th percentile) or mean seismic hazard curve may be selected. The mean seismic hazard curve is usually quite sensitive to uncertainties and, therefore, full inclussion of uncertainties in the seismic hazard analysis is necessary.

Two equally-permissible approaches can be used to quantify and propagate uncertainties in models and parameter values: the logic tree approach (e.g., EPRI, 1989a) and the Monte Carlo simulatiom approach (e.g., Bernreuter et al., 1989).

(4) Quantifying Uncertainty - Sec. 5.1.2.2.4 of DOE-STD-1023-95 provides detail discussions. Detailed recommendations for the application of expert elicitation and peer review are currently being developed as part of a study by the Senior Seismic Hazard Analysis Committee (SSHAC) sponsored by DOE, NRC, and EPRI (SSHAC, 1994). The guidance developed in this study will include such elements as: selection of the experts, methods of eliciting expert judgment, aggregation of expert judgments, role of the hazard analyst, and peer review procedures. The guidance will consider the uncertainties in both seismic source characterization as well as ground motion characterization. The guidance provided from he SSHAC study regarding these issues should be implemented as part of this standard.

Because the models and parameters of seismic hazard analysis are not known with certainty, hazard assessments should be designed to quantify not only the central tendenceis but also uncertainties. Two approaches are acceptable for characterizing and quantifying uncertainties in PSHA: elicitation of multiple experts and peer review (the approaches can be used separately or together).

In the first approach, the judgments of multiple experts are elicited regarding the elements of seismic sources and ground motion attenuation. The goal is to assess the uncertainties for any given expert and the range of diversity of interpretations among multiple experts.

A second approach to quantify uncertainties consists of a single analyst or contractor (such as a consulting company) conducting a seismic hazard analysis and subjecting the study to peer review by an independent panel of experts. The peer review should include review of the process as well as the inputs. The hazard analyst should strive to incorporate the range of scientific interpretations and the peer reviewers should ensure that all reasonable interpretations have been considered. Multiple cycles of peer review, focusing on particular components of the analysis, are often needed to allow for modification and updating of the inputs. The peer review approach has been applied at many DOE sites for seismic hazard analysis.

An important aspect of uncertainty characterization is documentation. Regardless of whether the expert elicitation or the peer review procedure is used, the technical basis for all assessments must be documented in a form suitable for third party review.

3.2.2.1 Simplified PSHA - For sites with facilities in Performance Category 3 or less, a simplified PSHA is acceptable. Simplifications are not in the methodology itself but rather in the extent to which the general principles of the methodology are fulfilled. In practice, the simplification is obtained by reducing the effort of new data collection, reducing the number of experts elicited or the level of peer review and by reducing the sampling and testing in the geotechnical field for the site-specific characterization. The SSHAC study should be consulted for guidance

3.2.2.2 Level of Review - The credibility and defensibility of a modern PSHA depends on the quality of the input as well as the completeness of the documentation. All the information, input, and analysis should be fully documented and independently reviewed. The independent review should focus on the arguments and logic used to develop the hazard results. The review team should include personnel with expertise in the seismic hazard methodology and input parameters. The review should be documented including questions raised by reviewers and resolutions provided by the analyst. The SSHAC study should be consulted for guidance.

3.3. Development Of DBE Response Spectra - Earthquake vibratory ground motion to be used as input excitation for design and evaluation of DOE facilities, according to DOE-STD-1020-94, is defined by a median deterministic site-specific response spectrum anchored to the mean peak ground motion parameters determined from the mean seismic hazard curve. When a site-specific response spectrum shape is unavailable, a median standardized spectral shape such as that defined in NUREG/CR-0098 may be used so long as such a spectrum shape is either reasonably consistent with or conservative for the site conditions.

The DBE ground motion at the site shall be specified in terms of smooth and broad frequency content horizontal and vertical response spectra defined at a specific control point. The location of the control point shall be specified at the ground surface for deep soil sites where the properties of the sites smoothly vary with depth. For sites composed of thin layer soil deposits (less than 100 feet) overlying rock or stiff soil, the control point shall be specified at the surface of the outcrop of the rock or stiff soil. If the control point is specified at other locations appropriate documentation shall be provided.

Methods that can be used for the development of site specific response spectra are described in Section 5.1.3.1 of DOE-STD-1023-95. Alternatively, methods commonly used for the development of standardized response spectra based on general site conditions instead of a site-specific geotechnical study are described in Section 5.1.3.2 of DOE-STD-1023-95.

For those sites that choose to develop a deterministic site-specific spectral shape, information contained in the probabilistic seismic hazard analysis should be used to establish the appropriate magnitudes and distances for the controlling (or dominant) earthquakes. Controlling earthquakes are those potential earthquakes that could cause the greatest or governing ground motions at a site. There may be several controlling earthquakes for a site, e.g., a moderate nearby earthquake may control the high-frequency of the ground motions or the PGA, and a large distance earthquake may control the low-frequency ground motions (e.g., 1-2.5 Hz) or the peak ground displacement (PGD).

The primary controlling earthquake is the postulated event that governs the spectral accelerations in the 5 to 10 Hz range. Thus, the primary seismic ground motion parameter is the average spectral acceleration of 5 to 10 Hz, $S_{A(5\text{-}10)}$. There may be some instance where spectrum generated from this controlling earthquake may not be significantly broad-banded to capture the contributions from all sources. Therefore, if the controlling earthquake for the frequency range of 1 to 2.5 Hz is from a significantly different source, e.g. a large, distant event, its effect on the spectral shape shall be examined and included. In addition, for sites that have SSCs which are sensitive to the low-frequency response (e.g., below 1 Hz), it may be necessary to include the controlling earthquake determined from the PGD.

An acceptable approach for the development of a deterministic site-specific DBE response spectra includes the steps summarized below.

Step 1: From the site-specific probabilistic seismic hazard analysis results use the mean seismic hazard curve showing the annual probability of exceedance as a function of the S_A.

Step 2: Using the appropriate annual probability of exceedance level (P_H), enter the hazard curve of Step 1 at P_H (e.g., $1x10^{-4}$ for PC4) to determine the corresponding S_A.

Step 3: Deaggregate the mean S_A seismic hazard curve as a function of magnitude and distance by calculating the contribution to the hazard for all of the earthquakes in a selected set of magnitude and distance bins of size MxN to determine the relative contribution to the hazard. This requires the calculation of the annual probability of exceedance, $H(m_i, r_j)$, for each of the bins centered at magnitude m_i and distance r_j, i.e., i=1,2,...,M and j=1,2,...,N.

Step 4: Compute the magnitude m(1) and distance r(1) of the controlling earthquake for the mean estimate of S_A (5-10) using the contributions $H(m_i, r_j)$ computed in Step 3 in accordance with the equations given in the standard, Sec. 5.1.3.1 DOE-STD-1023-95.

Step 5: Select from the site-specific PSHA results the mean seismic hazard curve for the ground motion parameter $S_{A(1\text{-}2.5)}$, i.e., the average spectral acceleration in the frequency range 1 to 2.5 Hz, and use the same P_H and Step 1 through 4 as above to determine the magnitude m(2) and distance r(2) that control the $S_{A(1\text{-}2.5)}$.

Step 6: Develop the (deterministic) median normalized response spectral shape for m(1):r(1) and, if necessary for m(2):r(2). Available methods are described in Section 5.1.3.1.e. of the standard.

Step 7: Scale the normalized spectral shape for m(1):r(1) to the $S_{A(5\text{-}10)}$ with the appropriate annual probability (e.g., 1 x 10^{-4} for sites not located near tectonic plate boundaries, containing facilities with SSCs in PC4).

Step 8: Determine if the scaled spectrum for m(1):r(1) envelopes the 1 to 2.5 Hz region of the m(2):r(2) spectrum. If not envelop the two resulting spectra to create a single response spectrum. The engineer/designer shall use the above single envelope spectrum or analyze twice, one for each m:r combination, and use the more conservative result for design purposes. It is intended that the resulting envelop will be a smooth, broad spectrum without significant gaps in spectral ordinates when compared to the mean uniform hazard spectrum.

3.4 Earthquake-Induced Ground Failure Assessment - In addition to ground shaking, another direct effect of earthquake can be surface expression of fault offset. A probabilistic assessment of this ground failure mode may be necessary if potential fault rupture may occur near a facility. If the annual probability of this ground failure mode is greater than the necessary performance goal, either the site should be avoided, mitigation measure taken, or an evaluation performed of the effects of fault offset.

An assessment should be conducted to determine the possibility of other ground failure modes such as liquefaction, slope instability, lateral spreading, or subsidence at a site.

3.5 Review of PSHA Results - In assessing the DBE, the review will consider historical earthquakes that may have affected the site and ensure that the DBE is conservative relative to the historical earthquake. Historical earthquakes are defined as any earthquake which has been felt or instrumentally recorded. Ground motion estimates will be completed for all historical earthquakes estimated to be equal to or above moment magnitude of 6.0, within a distance of 200 kilometers (124 mi) of the site. The only exception to this requirement is for sites within 500 kilometers (311 mi) of the 1811-1812 New Madrid earthquake sequence, which are required to include the ground motion from a reoccurrence of these events. Ground motion estimates shall be based on the following assumptions:

(1) Magnitude - The historical earthquake magnitude will be a best estimate of the moment magnitude for the earthquake. If instrumentally recorded, the magnitude will be either the recorded moment magnitude or a derived moment magnitude from other estimated magnitudes using accepted published magnitude conversion relationships. If the historical earthquake is a pre-instrumental event, the moment magnitude should be estimated using information such as the total felt area or other applicable intensity information found in the published literature and authoritative unpublished records, diaries, scientists notes, etc. If the ground motion attenuation relationship requires additional source parameters such as stress drop, these parameters should also be defined as best estimates.

(2) Distance - The distance should be based on a best estimate. For instrumentally recorded earthquakes, the distance should be based on the best available location (including depth). For pre-instrumental earthquakes, there is considerable uncertainty in the exact location of the event. In these cases, a reasonably conservative estimate should be provided which considers factors such as the highest intensity and the estimated rupture dimension for the magnitude being considered.

(3) Ground Motion - Both median (50th percentile) and 84th percentile estimates of ground motion should be completed for all frequencies comprising the response spectra. Methods for estimating ground motion should be consistent with the approaches used to derive the deterministic spectral shapes as discussed in Section 5.1.3.1 of DOE-STD-1023-95. For PC-4 facilities, the DBE spectra should be equal to or greater than the 84th percentile estimate. For PC-3 facilities, the DBE spectra should be equal to or greater than the median estimate. In general, the difference between the median and 84th percentile is about a factor of 1.7 to 2 in ground motion, which approximates the ground motion difference between PC-3 and PC-4 hazard probabilities coupled with typical hazard curve slopes.

4. DETAILED REQUIREMENTS FOR WIND HAZARD ASSESSMENT

Design and evaluation criteria for Department of Energy facilities against wind hazards are provided by DOE-STD-1020-94. In accordance with DOE-STD-1020-94, (1) the recommended basic wind speed for all Performance Categories; (2) the atmospheric pressure change (APC) associated with a tornado for Performance Category 3 or 4 SSCs; and (3) windborne missile criteria (size, weight, and speed) for Performance Category 3 or 4 SSCs; shall be defined in order to carry out the design/evaluation process.

Guidelines for the atmospheric pressure change and recommended windborne missiles are contained in DOE-STD-1020-94.

The recommended basic wind speed shall be determined from a mean wind hazard curve developed for the site in accordance with the hazard annual probability specified in DOE-STD-1020-94. The recommended basic wind speeds for 25 DOE sites are currently defined in

DOE-STD-1020-94. DOE Order 5480.28 requires that the need for updating the site wind hazard assessment be reviewed at least every 10 years. Therefore, for sites where existing wind hazard assessments are either unavailable or considered out of date, a new wind hazard assessment shall be conducted.

The purpose of this section of the Standard is to provide specific criteria for the DOE facilities with respect to the wind hazard assessment. The criteria is provided to ensure that a consistent approach across DOE sites is achieved for design/evaluation of DOE facilities against wind hazards.

In performing the wind hazard assessment, Section 4.a of this standard shall be complied with, i.e., a probabilistic wind hazard shall be conducted at a level appropriate for the performance categories of the SSCs at the site.

For sites containing facilities with SSCs in only Performance Category 1 or 2, missile effects and atmospheric pressure change due to tornadoes need not be considered. Therefore, the only wind hazard design parameter to be established is the basic wind speed.

(1) For sites having no site-specific probabilistic wind hazard assessment, it is sufficient to utilize model building codes such as ICBO (1991) or national consensus standards, such as ASCE (1993), to define the basic wind speed.

(2) For sites which have site-specific probabilistic wind hazard assessment, the SSCs in Performance Category 1 or 2 shall be evaluated for the greater of the site-specific values or the model code values unless lower site-specific values can be justified and approved.

For sites containing facilities with SSCs in Performance Category 3 or 4, a site-specific probabilistic wind hazard assessment is conducted to establish the wind speed for design and/or evaluation of the facilities.

The results of the probabilistic wind hazard assessment includes a mean wind hazard curve and other information regarding the uncertainty in the hazard assessment. The wind hazard curve represents the annual probability of exceedance as a function of wind speed at the site.

There are three types of winds: Extreme (straight) wind, hurricane, and tornado. Extreme (straight) winds are non-rotating such as those found in a thunderstorm gust front. Tornadoes and hurricanes both are rotating winds. All three types of winds shall be considered in the wind hazard assessment.

For practical purposes, the effects of hurricanes are treated the same as those of straight winds in accordance with DOE-STD-1020-94. As a result, both hurricane winds and straight winds will be represented by a single straight wind hazard curve although different wind hazard models are used for straight winds and hurricanes.

The site-specific probabilistic wind hazard assessment is characterized by the following traits:

(1) Probabilistic wind hazard assessments shall performed for straight winds, hurricanes, and tornadoes.

(2) The wind hazard assessments for straight winds and hurricanes shall be combined to produce a single straight wind hazard curve by assuming the two types of winds are mutually exclusive events. A composite probability distribution may be used to assess probability of exceedance of wind speeds (Changery, 1985). It is recommended to use a Gumbel distribution (Coats and Murray, 1985) to model straight wind hazards and a Weibull distribution (Simiu and Scanlan, 1986) to model hurricane wind hazards.

(3) A transition wind speed is defined by the intersection point of the combined straight wind hazard curve and the tornado wind hazard curve.

(4) The combined straight wind hazard curve is used as the actual wind hazard curve for wind speed up to the transition wind speed while the tornado hazard curve is used as the actual wind hazard curve for wind speed above the transition wind speed.

(5) The transition wind speed also determines if other tornado effects (e.g., APC and tornado missiles) need to be considered based on criteria specified in DOE-STD-1020-94.

Probabilistic hazard assessments for straight wind, hurricane wind, hurricane wind and tornado wind are listed respectively in Section 5.2.2.1, 5.2.2.2, and 5.2.2.3 of the DOE-STD-1023-95.

5. DETAILED REQUIREMENTS FOR FLOOD HAZARD ASSESSMENT

Design and evaluation criteria for Department of Energy facilities against flood hazards are provided by DOE-STD-1024-94. In accordance with DOE-STD-1024-94, a Design Basis Flood (DBFL) shall be established in order to carry out the design/evaluation process. The DBFL is a flood level determined from the mean flood hazard curve and the hazard annual probability of exceedance specified in Table 5-1 of DOE-STD-1024-94. A probabilistic flood hazard assessment is required to develop the flood hazard curve at the site.

The purpose of this section of the Standard is to provide specific guidelines to assess flood hazards for DOE facilities. This criteria is provided to ensure that a consistent approach across DOE sites is achieved for design/evaluation against flood hazards.

In accordance with Section 4.c of the standard, for sites containing facilities with SSCs in Performance Category 3 or 4, a site-specific probabilistic flood hazard assessment is required. A site-specific probabilistic flood hazard assessment at a site shall involve the following two steps:

Step 1: Perform a flood screening analysis to evaluate the magnitude of flood hazards that may impact the SSC's under consideration. Specific criteria for a flood screening analysis are provided in Section 5.3.2 of this Standard.

Step 2: Perform a comprehensive flood hazard assessment, if needed, based on the results of the flood screening evaluation. Specific criteria for a comprehensive flood hazard assessment are provided in Section 5.3.3 of this Standard.

In accordance with Section 4.d of the standard, for sites containing facilities with SSCs in only Performance Category 1 or 2 and having no existing site-specific probabilistic flood hazard assessment, it is sufficient to utilize flood insurance studies or equivalent to estimate the DBFL.

However, for sites containing facilities with SSCs in Performance Category 2, a reduced-scope site-specific probabilistic flood hazard assessment is required because most flood insurance studies available have not been conducted at a level which is compatible with the hazard annual probability of exceedance ($5x10^{-4}$) associated with Performance Category 2 SSCs. A reduced-scope site-specific probabilistic flood assessment shall contain only Step 1, i.e., a flood screening analysis, of the site-specific probabilistic flood hazard assessment as specified in Section 5.3.1.c. of the standard.

For sites which have site-specific flood hazard assessments, the SSCs in Performance Categories 1 and 2 shall be evaluated or designed for the greater of the site-specific values, flood insurance studies, or equivalent unless lower site-specific values can be justified and are approved.

The flood hazard assessment shall consider all the phenomena that can cause flooding (e.g., river flooding, storm surge, dam failure). The identification of potential sources of flooding is addressed in Section 5.3.2.1 of this Standard. In addition, all sites must design a site drainage system to handle the runoff due to local precipitation.

For each identified source of potential flooding, the flood hazard assessment shall consider all effects of flooding including submergence, waves and runups, debris, and hydrodynamic effects (e.g., peak flow velocity). For sites containing facilities with SSCs in Performance Category 1 or 2, it is sufficient to consider flood levels due to submergence, waves and runups.

For determination of the DBFL, the flood hazard assessment shall consider the possibility of simultaneous occurrence of flood events as specified in Section 5.3.4 of this Standard.

In completing a flood hazard assessment, it is extremely important that an accurate site-specific data base be available. DOE-STD-1022-XX provides criteria for the types of data that shall be collected and compiled for such a data base.

Flood screening analysis, comprehensive flood hazard assessment, flood even combinations, and review of flood hazard results are discussed in details in Sections 5.3.2, 5.3.3, 5.3.4, and 5.3.5 of this Standard, DOE-STD-1023-95.

6. SUMMARY

The draft DOE Standard DOE-STD-1023-95 has been prepared for compliance with DOE Order 5480.28 for natural phenomena hazard mitigation at DOE sites. DOE-STD-1023-95 provides criteria for hazard assessment to ensure that adequate design basis load levels are established for design/evaluation of DOE facilities subjected to natural phenomena hazards. The development of the draft standards is based on the state-of-the-art methodologies and procedures as well as the most recent available information and data. The drafts standards have been reviewed by DOE Community and the review comments are being resolved and incorporated into this Standard.

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