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DOE STANDARD

NATURAL PHENOMENA HAZARDS PERFORMANCE CATEGORIZATION GUIDELINES FOR STRUCTURES, SYSTEMS, AND COMPONENTS

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

AREA FACR

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ERRATA FOR DOE-STD-1021-93

ADDED REFERENCE TO 10 CFR PART 830

ADDED REFERENCE TO DOE G 420.1-2

ADDED REFERENCE TO DOE G 420.1-1

ADDED SENTENCE AT END OF 2.5 (a) CLARIFYING TWO OVER ONE PROTECTION

ADDED REFERENCE TO INTERNATIONAL BUILDING CODE 2000

UPDATED REFERENCE OF DOE-STD-1020-2002

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FOREWORD

Change Notice #1 was included in this standard to provide information to help meet the requirements in DOE Order 420.1 and its associated Guides, and to update this standard to the most current references.

This DOE standard is approved for use by all departments and contractors of the Department of Energy (DOE). This standard will still apply if and when DOE Order 420.1 is converted to a rule. In addition, this Standard will still apply when other referenced Orders are implemented by the 10 CFR Part 830 .

This standard provides guidelines to be used for Natural Phenomena Hazard (NPH) performance categorization of structures, systems, and components (SSCs), and recommends systematic procedures to implement these guidelines. It applies to all Department of Energy (DOE) facilities that are covered by DOE Order 420.1. 10 CFR Part 830 requires the use of a "graded approach" in performing safety analysis and evaluation of DOE facilities for normal operating and accident conditions, including accidents caused by NPH events. The NPH Guide to DOE Order 420.1 (DOE G-420.1-2) uses this "graded approach" and requires, for the purpose of NPH design and evaluation, placing the SSCs comprising the DOE facilities into five NPH performance categories.

NPH performance categorization guidelines provided in this technical standard are based on the system safety classification and hazard categorization/classification data obtained from the application of 10 CFR Part 830, DOE-STD-3009-94 (CHG-1), and DOE-STD-1027-92.

There is an established hierarchy in the set of documents that specify NPH requirements. In this hierarch, 10 CFR Part 830 is the highest authority followed by DOE O 420.1. The next sets of controlling documents are the associated guides DOE G 420.1-1 and 420.1-2 followed by the set of NPH standards. In the event of conflicts in the information provided by these documents, the information in the document of higher authority should be utilized (e.g., the definitions provided in the guides should be utilized even though corresponding definitions are provided in the NPH standards).

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this standard is as follows:

(a) To provide, for the purpose of Natural Phenomena Hazard (NPH) design and evaluation, criteria for selecting performance categories (PCs) of structures, systems, and components (SSCs) in accordance with the requirements specified in DOE Order 420.1 (Reference 10) and the NPH Guide to DOE O 420.1 (DOE G 420.1-2) (Reference 11).

(b) To recommend general procedures for consistent application of the above performance categorization criteria so that the Department of Energy (DOE) review and approval process is simplified.

1.2 Scope

The criteria and recommendations presented in this standard shall apply to performance categorization of SSCs for the purpose of mitigating natural phenomena hazards in all DOE facilities covered by DOE Order 420.1.

1.3 Background

For several years, design and evaluation of DOE facilities subjected to natural phenomena hazards were performed in accordance with the guidelines provided in UCRL-15910 (Reference 6) and DOE 5481.1B (Reference 3). The use of UCRL-15910 was referenced in DOE 6430. IA, General Design Criteria Manual. When DOE 5480.28 (Reference 1) was issued, UCRL15910 was superseded and issued as DOE-STD-1020-94 and now revised as DOE-STD-1020-2002 (Reference 9). Subsequently, DOE 5480.28 and DOE 6430.1A were superseded by DOE Order 420.1 and the associated guides, DOE G 420.1-1, 420.1-2.

To ensure that the level of conservatism introduced in the NPH design/evaluation process is appropriate for facility occupancy and other characteristics such as importance, cost, and hazards to people on and offsite and to the environment, UCRL-15910 used the "performance goal" as a "target" design/evaluation parameter. The performance goal for an SSC was defined as its annual frequency of probable failure to perform or annual probability of exceedance of acceptable behavior limits. Depending on the severity of consequences of SSC failure, the 1990 version of UCRL-15910 grouped the facilities into four usage categories, and assigned a target performance goal for each usage category. The four usage categories were: (i) General Use, (ii) Important or Low Hazard, (iii) Moderate Hazard, and (iv) High Hazard. No detailed guidance was provided in UCRL-15910 to perform this categorization.

In applying the UCRL-15910 methodology, facility usage categories were often correlated with facility hazard classes that were determined in accordance with DOE 5481.1B (Reference 3, for all facilities except nuclear facilities), DOE 5480.5 (Reference 7, for non-reactor nuclear facilities), and DOE 5480.6 (Reference 8, for nuclear reactor facilities). The three hazard classes that were used in these three orders (i.e., DOE 5481.1B, DOE 5480.5, and DOE 5480.6) were: (i) Low Hazard, (ii) Moderate Hazard, and (iii) High Hazard.

DOE Order 5480.23, *Nuclear Safety Analysis Reports* (Reference 2), issued in April 1992, required that DOE nuclear facilities undergo safety analyses and evaluation for all plant operating, accident, and extreme environmental conditions, including NPH. It required categorization of nuclear facilities into Hazard Category 1, 2, or 3, on the basis of consequences of unmitigated release of radioactive materials.[1] The definition of safety class SSCs is given in DOE 5480.30 *(Nuclear Reactor Safety Design Criteria,* Reference 4).

DOE Order 5480.28 established policy and requirements for NPH mitigation for DOE facilities. It required that the adequacy of SSCs comprising a facility must be defined based on target performance goals, and that the performance goals must be selected by considering the consequences of SSC damage/failure using a "graded approach." Accordingly, it required that, for the purpose of NPH design and evaluation, SSCs be placed in one of five performance categories, and established numerical performance goals as "aiming points" for each performance category. These numerical performance goals were the same as in UCRL-15910. A fifth category (Category 0) was added in DOE 5480.28 for SSCs that do not require NPH design, DOE-STD-1021-93 was developed to provide criteria and guidelines for assigning one of these five performance categories to SSCs using SSC safety classification and facility hazard categorization/classification data generated by or available from activities related to DOE Order 5480.23 and DOE-STD-1027-92 (or equivalent for non-nuclear hazardous facilities).

Subsequently, in 1994, DOE-STD-3009 (Reference 12) was issued to provide guidance for complying with DOE 5480.23. In 1995, DOE Order 420.1, along with its Guides, was issued. Since these documents provided key information and policy guidance for NPH performance categorization, this revision of DOE-STD-1021 was necessary. This standard provides revised guidelines for assigning SSCs to NPH performance categories that are integrated with the safety analysis process. The hierarchy for application of the NPH documents is: DOE Order 420.1, followed by the NPH Guide for DOE Order 420.1 (DOE G 420.1-2), and then the DOE NPH standards.

Although DOE-STD-3009-94 (CHG-1) and the SAR process it describes are specifically applicable to non-reactor nuclear facilities, it is DOE's intention to apply DOE-STD-3009-94 (CHG-1) definitions for "safety-class" and "safety-significant" SSCs to nuclear reactors and all hazardous facilities, and this broader application is implemented here.

Figure 1-1 conceptually shows the relationship of NPH performance categorization of SSCs to safety analysis activities and NPH design requirements.

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[1]It should be noted that DOE 5480.23 stated that an analysis and categorization is to be performed on “processes, operations, or activities,” and not necessarily whole facilities. Accident analysis identifies the physical relationships among the SSC and the release mechanisms for selected sequences.

1.4 Terminology

Throughout this document, the terms "higher" performance category and "lower" performance category are used. These terms refer to categories with more stringent or less stringent NPH mitigation requirements, respectively. As defined in the NPH Implementation Guide to DOE Order 420.1, performance categories range from 0 to 4 in order of increasingly stringent NPH mitigation and performance requirements and with decreasing values of annual probability of exceedance of acceptable behavior limits.

1.5 Organization of the Document

This standard has been developed and organized as an aid to the engineers and DOE facility managers who have the responsibility for selecting performance categories of SSCs per the NPH Guide for DOE Order 420.1 (DOE G 420.1-2).

Section 2 provides the criteria for selecting performance categories of SSCs. Section 3 presents recommended general procedures for systematic application of these criteria. This section also provides discussions and examples which will enable the user to understand and interpret the criteria correctly and easily. Section 4 lists the references cited.

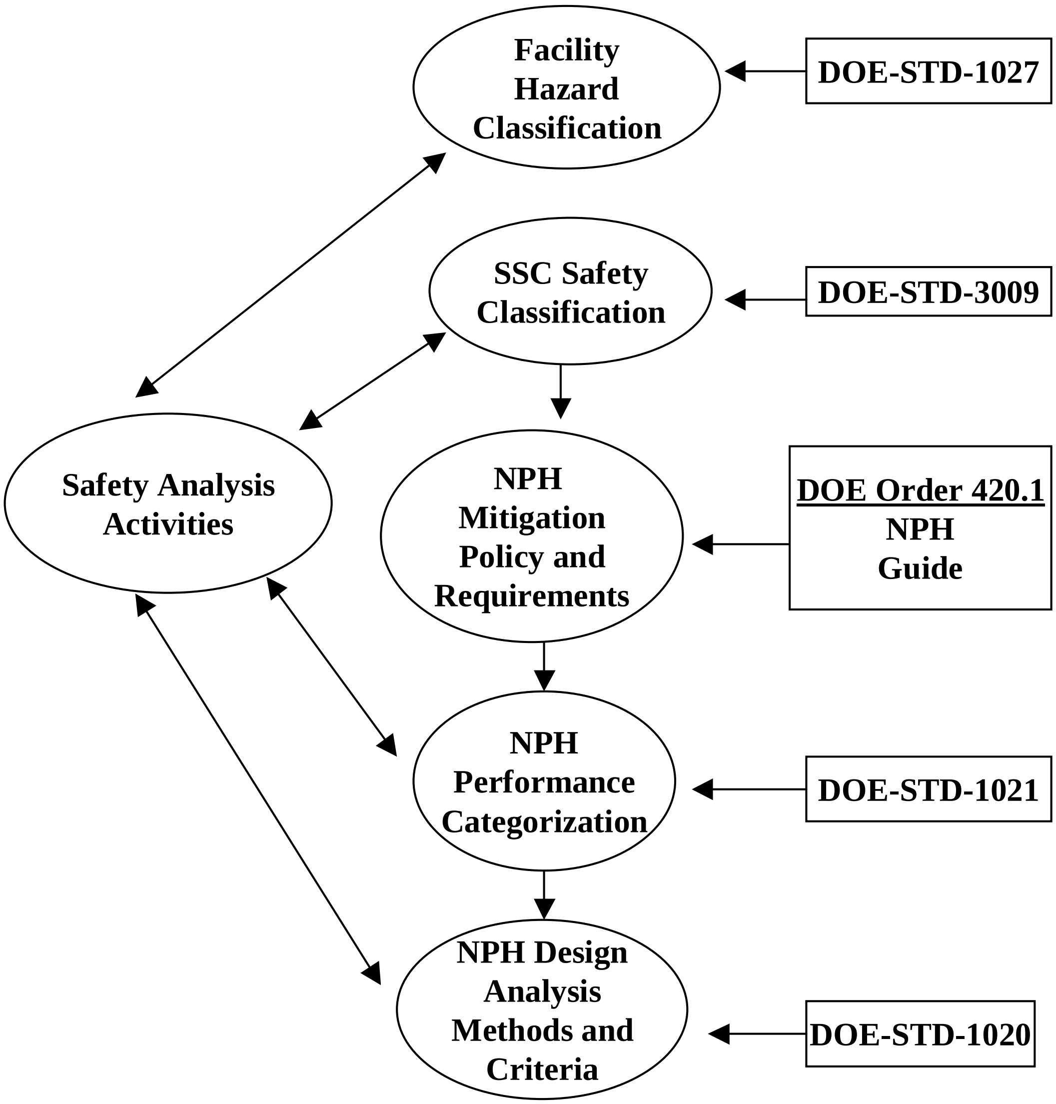

Figure 1-1
NPH Performance Categorization Relationship to Safety Analysis Activities and the NPH Design Standard.

2.0 GUIDELINES FOR SELECTING PERFORMANCE CATEGORY

2.1 General

(a) This section provides guidelines for selecting SSC performance categories that are consistent with the requirements of the NPH Guide for DOE Order 420.1 (DOE G 420.1-2), DOE-STD-3009-94 (CHG-1), 10 CFR Part 830, DOE 5480.30, and DOE 5481.1B. The provisions of this standard are intended to satisfy DOE Order 420.1 and the NPH Guide for DOE Order 420.1 with (DOE G 420.1-2) respect to performance categorization of SSCs.

(b) Provisions of this standard apply only to NPH evaluation of SSCs.

(c) The guidelines in this section have been reached through consensus engineering judgments with the objective of satisfying DOE's NPH safety policy. However, each facility manager shall consider all facility-specific safety, design, and performance issues while applying these guidelines.

(d) Guidelines provided in this section are intended to satisfy the minimum NPH mitigation requirements of DOE Order 420. 1. However, an SSC may be placed in a performance category that is higher than the category determined on the basis of these guidelines if it is considered necessary from cost or mission considerations.

(e) Personnel performing SSC categorization shall have thorough understanding of operations and safety bases of the systems and facilities to which these SSCs belong. They also shall have the necessary experience, technical knowledge, and understanding of safety-class and safety-significant SSCs as defined in the requirements of DOE-STD-3009. This standard provides guidelines and recommends procedures for performing the necessary tasks.

(f) Performance categorization shall be initially performed considering the basic categorization guidelines (see Subsection 2.4), that will establish the preliminary performance category. The preliminary performance category shall then be modified by considering applicable system interaction effects (see Subsection 2.5), which are also known as "two over one protection" in the nuclear industry.

2.2 Data Sources

(a) Data and information necessary for applying the guidelines given in this standard shall be obtained from the design basis system studies, accident analyses, and calculations performed for the following purposes:

(i) Hazard classification of all facilities, except nuclear facilities, in accordance with DOE O 5481.I B (Reference 3) which results in facility hazard classes: High Hazard (HH), Moderate Hazard (MH), and Low Hazard (LH).

(ii) Hazard categorization of nuclear facilities in accordance with DOE-STD-1027-92 (Reference 5) which results in facility hazard categories HC1 (highest), HC2, and HC3 (lowest).

(iii) Safety classification of SSCs determined in accordance with DOE O 5480.30, DOE O 5481.I B, and DOE-STD-3009-94 (CHG-1).

(iv) Identification of SSCs whose failure may adversely affect the general life safety of facility occupants as described in the NPH Implementation Guide to DOE Order 420.1 (DOE O 420.1-2).

(b) Additional data or information needed may be obtained by referring to design documents and facility accident analyses.

2.3 Safety Classification of Structures, Systems, and Components

(a) For performance categorization of SSCs in accordance with this standard, "safetyclass"and "safety-significant" SSCs shall be as defined in DOE-STD-3009-94 (CHG-1) and DOE O 5480.30.

(b) An SSC, failure of which may impair or adversely affect an operator action that is required for safety during and following an NPH event, shall also be treated as a safety-class or safety-significant SSC for the purpose of selecting performance category in accordance with this standard.

(c) Even if an SSC is not classified as safety-class or safety-significant according to the provisions of Paragraphs (a) and (b) above, it shall be treated as such if its failure by itself or its common-cause failure with one or more SSCs result in the nonperformance of a safety function identified in the safety analysis.

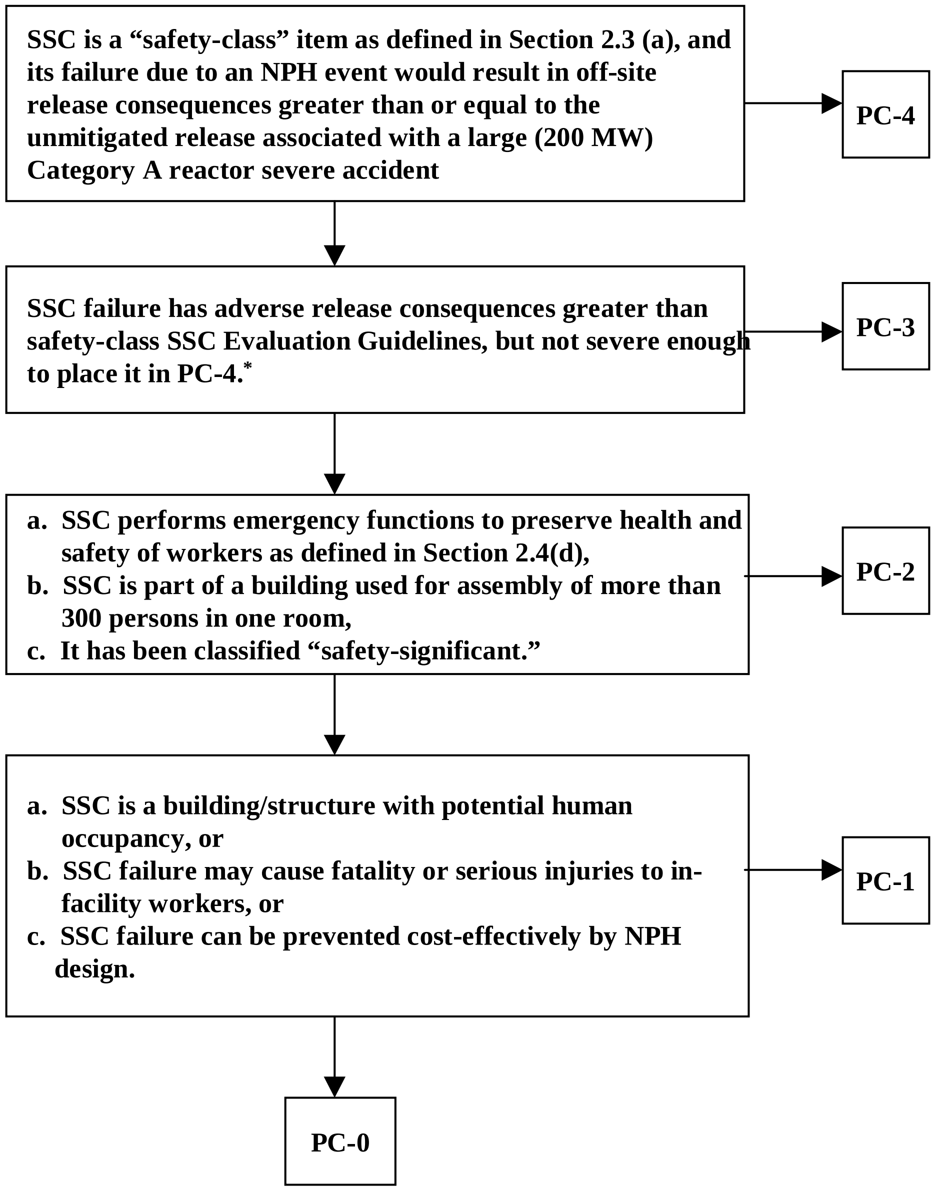

Figure 2-1
Basic Guidelines for Preliminary NPH Performance Categorization of Structures, Systems, and Components

Notes:
SSC = Structure, System, or Component
Use this Figure only in the context of Section 2 of this document; also see Subsection 2.5 for System Interaction Effects
* Also Refer to DOE-G-420.1-2 for additional applications.

2.4 Basic Categorization Guidelines

(d) The basic categorization guidelines are summarized in the flow chart shown in Figure 2-1 and described in the following paragraphs category by category. The guidelines presented here assume that the hazard categorization/classification, accident analyses, and identification of safety-class and safety-significant systems for facilities that store, handle, or process radioactive and toxic materials have been performed and documented in accordance with applicable DOE Orders and standards as listed in Subsection 2.2 and the requirements of Subsection 2.3 above. It is also assumed that the mission and functional/performance requirements of SSCs in facilities not covered by the above-referenced DOE Orders/standards are known, or have been determined.

The application of the basic categorization guidelines presented here will establish the preliminary performance category of SSCs. The preliminary performance category may not account for system interactions, if any, that are described in Subsection 2.5 below, but shall account for common-cause failure effects as discussed in Paragraph 2.3(c) above. It is to be noted that the hazard categorization is based on a method for assessing risk from potential hazards and follows the graded approach discussed in the NPH Implementation Guide for DOE Order 420.1 (DOE G 420.1-2).

(b) Performance Category 4: An SSC shall be placed in preliminary Performance Category 4 (PC-4) if it is a "safety-class" item as defined in STD-3009-94 (CHG-1) and Section 2.3, above, and if its failure during an NPH event could result in off-site release consequences greater than or equal to the unmitigated release from a large (>200 MWt) Category A reactor severe accident. There are not expected to be many such facilities in the DOE complex. Not all safety-class SSCs are necessarily *PC-4. If* the adverse off-site consequences from an NPH event are significant enough to make them safety-class but are substantially less than those associated with consequences from an unmitigated large Category A reactor severe accident, the SSCs should be placed in PC-3. An SSC that does not satisfy the above criteria may also be placed in PC-4 for improved performance if justified from cost-benefit considerations.

(c) Performance Category 3: An SSC shall be placed in preliminary Performance Category 3 (PC-3) if it is not covered in Paragraph 2.4(b) above, and if: its failure results in adverse release consequences greater than safety class SSC Evaluation Guidelines limits but much less than those associated with PC-4 SSCs.

For additional applications refer to DOE-G-420.1-2.

An SSC that does not satisfy the above criteria may also be placed in PC-3 for improved performance if justified from cost-benefit considerations. For new facilities, since it may not cost too much more to design the facility as PC-4 instead of PC-3, it may be desirable to design such PC-3 facilities in the conceptual design stage to PC-4 criteria, subject to funding constraints.

(d) Performance Category 2: An SSC shall be placed in preliminary Performance Category 2 (PC-2) if it is not covered in Paragraphs 2.4(b) and 2.4(c) above, and if any of the following conditions apply:

(i) The SSCs failure by itself or in combination with one or more SSCs may result in loss of function of any emergency handling, hazard recovery, fire suppression, emergency preparedness, communication, or power system that may be needed to preserve the health and safety of workers and visitors. This includes NPH-caused release of radioactive and toxic materials that would result in these consequences.

(ii) The SSC is part of a building which is primarily used for assembly of more than 300 persons (in one room), and the SSC failure may adversely affect the life safety of the occupants.

(iii) The SSC has been classified "safety-significant." For details refer to DOE-G-420.1-2.

An SSC that does not satisfy the above criteria may also be placed in PC-2 from cost and mission considerations, e.g., when SSC failure causes excessive downtime, the SSC is very difficult to replace, or SSC replacement/repair is very costly.

(e) Performance Category 1: An SSC that is not covered in Paragraphs 2.4(b), 2.4(c), and 2.4(d) above shall be placed in preliminary Performance Category I (PC-1) if any of the following conditions apply:

(i) It is a building/structure with potential human occupancy.

(ii) The SSC's failure may cause a fatality or serious injuries to in-facility workers.

(iii) The SSC's failure may cause damage that can be prevented or reduced cost-effectively by designing it to withstand NPH effects.

(f) Performance Category 0: An SSC that is not covered in Paragraphs 2.4(b) through 2.4(e) above may be placed in preliminary Performance Category 0 (PC-0), if it is not important because of safety, mission, or cost considerations, and if it is more cost-effective to replace or repair it than to design it to withstand NPH effects; however, an SSC whose failure may have any adverse effect on the performance of a PC- 1, PC-2, PC-3, or PC-4 SSC shall not be placed in PC-0.

2.5 System Interaction Effects ("Two Over One Protection")

(a) An SSC that has been placed in a preliminary performance category in accordance with the basic categorization guidelines of Subsection 2.4 (designate it as "source") shall have appropriate additional NPH mitigation requirements as provided in paragraphs (b), (c), and (d) below, if its behavior by itself, or the multiple common cause behavior of it with other SSCs may adversely affect the performance of another SSC (designate it as "target"). These additional requirements will depend on the type of source behavior that causes adverse interaction with the target during or following an NPH event. System interaction may be between one SSC and another SSC or one facility as a whole with another facility, in which case similar consideration should be given for design of the facilities appropriately.

(b) If the source behavior that causes adverse interaction is within the acceptable behavior limits of the source, i.e., if the adverse interaction occurs before source failure, adequate measures shall be taken to preclude such interaction and to ensure that the performance goal for the target is preserved. For example, assume that the postulated seismic deflection of a PC-1 cabinet (source) is within its own acceptable behavior limits, but the cabinet can potentially impact and cause the failure of a PC-2 fire-suppression component (target). To prevent this adverse interaction, the cabinet support system or the cabinet itself can be stiffened/strengthened in such a way that the calculated deflection of the cabinet towards the target, when subjected to a seismic level corresponding to the performance category of the target, is less than the available clearance by a factor equal to the applicable design margin for the target. Alternatively, a barrier can be provided to preclude the adverse interaction and to protect the target. Such a barrier shall be designed to withstand NPH effects combined with the interaction effects from the source (in this case the impact from the PC-1 cabinet). To ensure that the target performance goal is preserved, the barrier shall be placed in the same performance category as the target (in this case PC-2).

(c) If the adverse interaction is possible only after the source fails or exceeds its acceptable behavior limits, either of the following two requirements shall be met to preclude adverse interaction:

(i) The source shall have additional NPH requirements corresponding to the performance category of the target, if the failure potential of the target, given the failure of the source, is assessed to be high. However, these additional requirements can be restricted to the source failure mode related to the adverse interaction effects. If the target failure potential is assessed to be low, no additional NPH mitigation requirements need to be applied (see Table 2-1).

(ii) Adequate measures shall be taken to preclude adverse interaction and to ensure that the performance goal for the target is preserved. Examples of acceptable measures are: stiffening/strengthening of the source structure or support system, relocating the source and/or the target, installing barriers, installing new components, modifying existing components, or any combination of these measures.

(d) If the behavior or failure of a source can adversely affect the performance of more than one target, the source shall have additional NPH requirements corresponding to the highest performance category that is determined by applying the rules provided in Paragraphs (a), (b), and (c) above separately for each target.

Table 2-1
System Interaction Effects on Performance Categorization

Performance Category of Target SSC[1]	Performance Category of Source SSC[2]	Potential for Interaction[3]	Revised NPH Requirements of Source SSC[4]
PC-4	PC-3	High	PC-4
		Low	PC-3[5]
	PC-2	High	PC-4
		Low	PC-2[5]
		High	PC-4
	PC-1	Low	PC-1[5]
PC-3	PC-2	High	PC-3
		Low	PC-2[5]
	PC-1	High	PC-3
		Low	PC-1[5]
PC-2	PC-1	High	PC-2
		Low	PC-1[5]

Notes:

(1) If the target consists of more than one SSC, the highest performance category of the group shall be considered here.

(2) This is the preliminary performance category of the source SSC before considering system interaction effects. Note that PC-0 is not considered here because, per Section 2.4(f), a PC-0 SSC cannot have any adverse effect on the performance of PC-1 through PC-4 SSCs.

(3) This is the qualitative assessment of the potential for target SSC failure, given that the source SSC will fail and interact with the target SSC due to NPH effects.

Thus, if the target is a PC-4 SSC that may be adversely affected by the failure of a PC-2 SSC (source), and if the target failure potential due to this interaction is high, then one of the methods of precluding the interaction will be to subject the source to additional NPH requirements corresponding to PC-4 (see also note 4 below).

(4) The source SSC shall be designed/evaluated to those requirements of the revised performance category that are essential for precluding adverse interaction with the target (in other words, it is not necessary to satisfy the functional requirements of the source SSC when subjected to these additional NPH requirements unless essential for precluding adverse interaction).

The basis for determining the revised NPH requirements for the source SSC is that the performance goal of the target SSC shall not be compromised because of system interaction effects.

(5) For these cases, consideration of interaction effects does not require additional NPH requirements for the source SSC.

3.0 RECOMMENDED APPLICATION PROCEDURES

3.1 General Notes

(a) In this section a set of procedures is recommended for systematic application of the guidelines presented in Section 2 of this document. General informational notes are presented in Subsection 3.1, and procedural steps for categorizing SSCs are provided in Subsections 3.2 through 3.10.

(b The procedural steps presented in this section are general recommendations for NPH performance categorization only, and are not intended to provide procedures for performing facility safety reviews or accident analyses. Depending on the design, safety analysis, and NPH evaluation history of the facility, and the availability of pertinent data and information, actual procedures to be followed for performance categorization may vary from facility to facility. However, general adherence to the procedures presented here will lead to a comprehensive and defensible NPH performance category list of SSCs that will be easy to review by DOE.

(c) Procedures presented here assume, in general, that systematic safety and accident analyses and hazard categorization/classification for the facility under consideration have been performed in accordance with DOE-STD-1027, DOE Order 420.1, DOE-STD-3009-94 (CHG-1), and other applicable DOE Orders and standards, and that the data and information generated during these activities are available for use during the NPH performance categorization process (see Subsection 2.2). Safety and accident analyses and hazard categorization that are yet to be undertaken, or are in process, should be performed by taking into account the data/information requirements for SSC performance categorization as outlined in this document.

(d) Following the "graded approach," the level of effort directed toward performance categorization, using the procedural steps presented in this section, should be in proportion to the safety, mission, and cost significance of the SSC being categorized and the facility to which the SSC belongs. As discussed in 10 CFR Part 830, DOE-STD-3009-94 (CHG-1), and in the NPH Implementation Guide to DOE Order 420.1, hazard is used as only one consideration in the graded approach concept, Categorization of safety-class and safety-significant SSCs as defined in Section 2.3 shall heavily rely on accident analysis of the facility if available. Whenever questions concerning appropriate categorization arise, provide a margin of error by selecting the higher category.

3.2 Procedural Steps

The NPH performance categorization process can be divided into the following procedural steps:

Step 1: Assign Facility Performance Categorization and Coordination Engineer.

Step 2: Survey pertinent documents and prepare a source document list.

Step 3: Organize SSC safety classification and accident analysis data from facility safety analyses.

Step 4: Determine preliminary performance category of NPH-related safety system components.

Step 5: Determine preliminary performance category of non-safety components.

Step 6: Determine failure potential of the target due to interaction with the source (Section 2.5).

Step 7: Apply interaction rules to modify preliminary performance categories (Section 2.5).

Step 8: Prepare final NPH performance category list.

These steps are described in detail in the following subsections.

3.3 Facility NPH Performance Categorization and Coordination Engineer

A Facility NPH Performance Categorization and Coordination Engineer knowledgeable in the operations and safety bases of the facility should be assigned to coordinate and direct the NPH performance categorization activities. He/she will be responsible for coordinating the development of a performance category list of all SSCs in the facility. It is desirable that the Performance Categorization and Coordination Engineer possess the following qualifications:

(i) Understanding of the mission, the basic function, and operation of the facility.

(ii) Familiarity with the layout of various SSCs comprising the facility.

(iii) Understanding of the functioning of the various SSCs, their NPH-related vulnerabilities, and their interactions with each other, and knowledge of the accident analysis of the facility.

(iv) Understanding of "safety" SSC design requirements as given in DOE-STD-3009-94 (CHG-1) and in Section 2.3. For all nuclear and hazardous facilities, safety SSCs shall be identified from the facility safety analysis.

(v) Familiarity with the facility design, design evaluations, design reviews, and design modifications.

(vi) Ability to interface with various design, engineering, safety, and operation groups of the facility.

3.4 Review of System Safety Classification and Accident Analysis Data

For the purpose of the NPH performance categorization process, a typical facility is assumed to consist of:

- Several systems, each consisting of many components and each performing a major and distinct safety-related and/or mission-related function, and/or

- One or more buildings that house one or more systems, or part of a system (a building may also act as a shield or barrier, or as part of a confinement/containment system), and/or

- One or more structures (such as a stack or a tank), inside or outside the facility buildings, that perform a major function, sometimes distinct and sometimes in support of another system.

For the purpose of performance categorization using the procedures outlined here, a facility will be considered to consist of systems, and systems will be considered to consist of components. Also, when a building or a structure performs a major and distinct function, either by itself or together with other components, it will be referred to here as a "system."

From a review of the pertinent documents, identify and list the systems that constitute the entire facility under consideration. In general, this list will consist of safety systems (as defined in Sections 2.2 and 2.3) and other systems. Frequently, not all the safety systems are essential for NPH mitigation. For example, even though certain SSCs are required for maintaining operating parameters within safety limits during normal operations and anticipated operational occurrences, these may not be essential for NPH mitigation.[2]

For systematic performance categorization, the facility systems can be represented in a matrix by letters of the alphabet, and "safety" functions can be represented by numbers (see Table 3-1). Entries in this matrix should be alphanumeric. The alphabet part of the entry will represent the system that is essential for the function represented by the numeric part of the entry. Thus, in the example matrix of Table 3-1, entry D1 shows that System D is essential for confinement/containment (Function No.1), and entry D3 shows that System D is also essential for providing radiation protection (Function No.3). The components in System D that are essential for confinement/containment may not be the same as the components that are essential for radiation protection, although some components may contribute to both functions.

Entries in the safety system-function matrix will identify the safety systems (including buildings or structures that perform a distinct function) that are essential for mitigating NPH-related accidents only. Thus, if an entire system column is without any entry, that system is not essential for NPH mitigation (e.g., System G in Table 3-1).

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[2] The Safety Analysis Report of the facility shall be used extensively in categorizing the SSCs.

Table 3-1
Safety System-Function Matrix
(For Illustration Only)

Facility Name: XXX
Facility Hazard Category: I

Function (1)	Safety Systems(2)							
	A	B	C	D	E	F	G(3)	H
1. Containment/Confinement	A1	-	C1	D1	-	-	-	H1
2. Safe Shutdown or Safe-State Maintenance	-	B2	C2	-	-	-	-	H2
3. Maintaining Nuclear Subcriticality or Radiation Protection	-	B3	-	D3	-	-	-	H3
4. Monitoring Radioactivity, Criticality or Toxicity	-	-	-	-	E4	-	-	H4
5. Emergency Handling, Hazard Recovery, etc.	-	-	-	-	E5	F5	-	-
6. Control or Support of Above Safety Functions.	A6	-	-	-	-	-	-	H6

Notes:

1. The functions are listed for illustration only; obtain actual description of functions from SAR related documents.

2. Attach brief description of each system with layout sketches showing location, boundary, and interface. All safety systems, including those which do not have NPH-related safety functions, should be listed here for completeness, ease of checking, and record-keeping purposes.

3. System G is an example of a case where a system can be classified as a safety system in the SAR, but may not have any NPH-related safety significance. Such systems shall be treated as “other” systems for the purpose of performance categorization of their components (see Subsection 3.4).

Safety systems whose columns have one or more entries are then identified as the NPH related safety systems of the facility.

Thus, for the purpose of performance categorization, the entire facility can be divided into three groups of systems:

Group I: Safety systems (see Section 2-3) that must function during and/or after an NPH event.
Group II: Safety systems not in Group I above.
Group III: Other systems that do not perform any safety function by themselves,

Components in Group I systems that perform any of the safety functions listed above will be preliminarily placed in PC-4, PC-3, or PC-2, according to the basic categorization guidelines of Subsection 2.4 and using the procedures described in Subsection 3.5 below. Other components in Group I systems that, using graded approach, do not belong there, along with the components in Group II and Group III systems, will be preliminarily placed in PC-2, PC-I, or PC-0, according to the criteria of Subsection 2.4 and using the procedures described in Subsection 3.6 below, unless they are placed in higher performance categories for improved performance (see Section 2.1[d]). These preliminary performance categories will then be modified to account for potential system interaction effects, in accordance with the guidelines given in Subsection 2.5 and using the procedures given in Subsections 3.7 and 3.8 below.

3.5 Determination of Preliminary Performance Category for NPH-Related Safety System Components

The components of the NPH-related safety systems (i.e., Group I systems) can be preliminarily categorized according to the guidelines provided in Subsection 2.4 and using one of the three methods presented below. The methods are presented in order of increasing rigor or decreasing conservatism. Following the "graded approach" philosophy, the method to be used should be selected on the basis of cost-benefit considerations. The end result of this step will be a preliminary performance category list for the NPH-related safety system components of the facility.

(a) Method 1: System-by-System Categorization

In this method, the performance category of a given component of a safety system (identified by an entry in the safety system-function matrix, see Table 3-1) will be the same as the highest performance category applicable to any component of the system per Subsection 2.4 guidelines, irrespective of the safety function of the particular component. Thus, all the components of a system will have the same performance category. This is the most conservative of the three methods and the only applicable method if the safety function of only the entire system is known, and information on the safety function of individual components of the system is unavailable. This method is preferable in the following situations:

(i) To select an initial performance category that can be used to determine the preliminary design hazard level (e.g., seismic acceleration level) for the component. If the component design is evaluated to be inadequate for the preliminary hazard level, or if the preliminary hazard level leads to an expensive design or requires a design change, a less conservative categorization method (Method II or III, see below) should be used.

(ii) When available data/information from system safety and accident analyses or from other sources are not adequate for Methods II and III, and generating additional data is not cost-effective.

(iii) When system configuration is such that designing its constituent components to unequal NPH levels is not cost-effective, or can cause significant uncertainty in the functional integrity of a higher category component. For example, consider a length of piping that does not perform any safety functions, but is attached to a PC-4 tank or pressure vessel (say, separated by an isolation valve). If the configuration of its interface (penetration or attachment) with the vessel is such that the failure of the pipe increases the uncertainty in the functional integrity (say, leak-tightness) of the vessel, it may be more cost-effective to design this piping system up to the isolation valve or possibly to the first anchor point as a PC-4 system, than to demonstrate that the piping failure would not result in the local failure of the vessel (or to evaluate system interaction effects necessary to assign a lower performance category to the piping system).

(b) Method II: Segment-by-Segment Categorization

A segment of a system is defined here as a group of components (mechanical, electrical, piping, structural, etc.) that perform one of the safety functions listed in Table 3-1 (or any other distinct subfunction). It may also be defined as a group of components belonging to a system that are physically located in a certain area, room, or building, or whose functions are such that it may be more cost-effective, or programmatically more desirable, to design or procure them using the same NPH design criterion.

In Method II, all components belonging to a segment of an NPH-related safety system (i.e., a system for which there is an entry in the safety system-function matrix, see Table 3-1) are placed in the highest performance category of any component in that segment, as applicable, according to Subsection 2.4 guidelines. The use of Method II is illustrated through the following example.

System B in Table 3-1 has two segments, B2 and B3, that constitute the safety part of the system (the components of the rest of System B are non-safety components). If categorization Method II is used, all components of Segment B2 will be placed in one performance category that corresponds to the safe shutdown or safe-state maintenance function. Similarly, B3 components will be placed in one performance category that corresponds to the nuclear criticality maintenance function. Components common to both segments will be placed in the higher category.

Method II categorization is more rigorous than Method I, since it allows assigning different segments to different categories, and assigning non-safety segments and components to applicable lower performance categories. However, Method I is more conservative.

(c) Method III: Component-by-Component Categorization

In this method, each component of the NPH-related safety systems (having an entry in the safety system-function matrix) is categorized individually following the Subsection 2.4 guidelines. Thus, each component is categorized based on its own function, and not lumped with the entire segment or system.

Method III is the most rigorous of the three methods, but the other two methods are more conservative. Use of this method can minimize the number of higher category components, and thereby reduce the components that must be designed for higher level NPH design loads. However, in order to accomplish this, detailed system safety and accident analyses will be needed.

3.6 Determination of Preliminary Performance Category for Non-Safety Components

Other components in a facility will consist of Group II and Group III system components (see Subsections 3.4 and 3.5), and the Group I system components that are not essential for NPH mitigation. Preliminary performance category of these components can be determined using a procedure similar to that described in Subsection 3.5 (i.e., by using system-by-system, segment-by-segment, or component-by-component categorization), except that categorization will be based on mission, worker and co-located worker life safety, and cost considerations as outlined in Paragraphs (d), (e), and (f) of Subsection 2.4. Accordingly, these components will be placed in PC-2, PC-1, or PC-0 (unless these are placed in PC-3 or PC-4 for improved performance consideration only).

The data and information necessary to categorize these components may be partially available in the facility hazard categorization documents or facility safety and accident analysis reports. If the available data are not adequate, additional data can be obtained cost-effectively through a facility walkdown (for existing facilities) and by interviewing facility operations and maintenance personnel. It may also be necessary to review design documents and operation manuals and procedures.

According to Section 2.4 guidelines, if the failure of a component can cause a life-threatening situation (non-radiological or non-toxic) to any worker or co-located worker, it would be a PC-1 component. Since radiological and toxicity effects have already been considered in Subsection 3.5, only physical life-threatening situations, such as those resulting from NPH-related structural failures or overturning of equipment, need to be considered in this step. Typical examples of such situations are when structures, tall heavy furniture, equipment, piping, ducts, etc., fall on people during NPH events or prevent egress of occupants. Components, failures of which can cause these situations, can be identified most effectively by a facility walkdown or by a careful evaluation of building layout plans and drawings. A convenient and efficient method of categorizing a large number of these types of SSCs would be to group them on the basis of their NPH related characteristics or locations. For example, for seismic hazard mitigation, it may be generically determined that furniture and equipment located below a certain elevation and having more than a certain base width-to-height (total height or center of gravity height) ratio would not cause any significant life-threatening situation for workers or occupants, and so can be generically placed into PC-0, thereby avoiding item-by-item evaluation. Similarly, for flood hazard mitigation, it may be obvious that SSCs (e.g. equipment, furniture, water-sensitive electrical or mechanical components, etc.) above a certain elevation would not be adversely affected during a flood event, and so can be lumped into one performance category (provided it is compatible with other functional/performance requirements). Once the SSCs are grouped, it is often possible to develop generic methodologies or procedures to establish the adequacy of such components against NPH events. For example, a generic procedure may be developed to anchor racks above a certain height (or some other critical parameter) and place these as a group in Performance Category 1.

If the cost or difficulty of replacing a component is estimated to be "excessive," the component would belong to PC-2, according to Subsection 2.4 guidelines (unless it is placed in a higher category for improved performance).

Also, if the facility downtime resulting from the failure of a component is judged to be "excessive," the component should be placed in PC-2 (unless for improved performance the facility manager chooses to place it in PC-3 or PC-4). The definition of "excessive" downtime will depend on the type of facility, its mission, its strategic importance, and the suitability of available alternatives, if any. Maximum permissible downtime is a basic design requirement, and should be established as a policy level issue specifically for each facility with appropriate DOE approval. Prediction of downtime should be based on a task-by-task schedule for the replacement of the failed component. This schedule can be an approximate one, based on time-estimates obtained by interviewing personnel responsible for design modification, procurement, operation, maintenance, and construction/installation.

SSCs that must be safe and usable for emergency purposes after an NPH event in order to preserve the health and safety of the workers and co-located workers, as well as members the general public, should also be placed in PC-2. Examples of such SSCs are those that are essential for the operation and functioning of:

- hospitals or other medical facilities having surgery or emergency treatment areas,
- fire stations,
- police and security stations,
- emergency communication centers,
- emergency power facilities, etc.

If the replacement or repair of a component is more cost-effective than designing it to withstand loads from NPH, then, according to Section 2.4 guidelines, it can be assigned to PC-0, provided the component is not important from life safety or mission considerations. In a typical facility, there are a large number of components that may be candidates for PC-0. In many cases, simple installation of anchors or braces (for earthquake, wind, and tornado loads) or placing the component at a different elevation or location (for flooding situations) will enable the component to withstand the NPH effects (i.e., the component will qualify at least as a PC-1). In some cases, it is often more cost-effective to do so rather than to demonstrate that the component is not important from life safety or mission considerations (especially to determine the effect of its failure on other safety-related or important components). On the other hand, there are cases in which the component location and/or configuration is such that providing, for example, required seismic braces or anchorages can be so difficult that it is more costly than replacing the component itself. In such cases, the component should be assigned to PC-0.

"Engineering judgment" will play a big role in determining the performance category of these components. Such judgment should be exercised with emphasis on the "graded approach" philosophy. Accordingly, the level of effort for such categorization should generally be at par with that usually spent for identifying "essential" facilities when a International Building Code (IBC 2000) type of design is adopted.

3.7 Assessment of System-Interaction Related Target Failure Potential

To account for adverse system interaction, Subsection 2.5, Paragraph (c)(i), requires an assessment of the failure potential of the target component, given the failure of the source component. Depending on the physical and functional complexity of the target and the nature of its interaction with the source, the level of effort for assessing this target failure potential can vary. Following the "graded approach" philosophy, the rigor with which such failure potentials are to be determined should depend on the safety significance and the preliminary performance category of the target, the hazard category of the facility, and the relative costs of various methods of determining target failure potentials.

In the following paragraphs, two methods of assessing target failure potentials are presented in order of decreasing rigor:

(a) <u>Systematic Analysis Method</u>

Target failure potentials can be assessed using a qualitative but systematic approach by constructing a fault-tree of the scenario. If justifiable from cost-benefit considerations, this may be a desirable method when necessary data for fault tree construction are available. Generally, it should be used when the failure of the target is dependent on a large and complex chain of events that may follow the failure of the source, or to qualify a large system in its entirety. Component-by-component application of this method is unlikely to be cost-effective.

(b) Approximate Method

In this method, the effects of source failure on a target are modeled approximately but rationally, considering possible scenarios identified by a facility walkdown. Even though such models are approximate, their evaluation provides qualitative information that is often adequate for the purpose. Examples of this method are given in Section 3.9.

3.8 Application of System Interaction Rules

The consideration of adverse effects of system interaction of one component or system (source) on another (target) is very important in determining the performance categories of SSCs. Adverse interaction effects can be different for different systems. Examples of typical adverse interaction effects are:

(i) Structural Failure and Falling: Inadequately designed, inadequately anchored, and unanchored components may fail, slide, and/or topple and fall on or bump into other components that are not designed to withstand such interaction effects.

(ii) Proximity and Impact: Adjacent components may impact each other, causing damage if the clearance between them is inadequate for NPH-induced deflections. Such adverse interaction may occur even if the deflection of the source is within its design limits.

(iii) Differential Displacement: A target distribution system (e.g., vital cable trays, pipes, ventilation ducts) may span between different structural systems (source). Differential displacements between the structural systems may be within acceptable behavior limits for the structures, but may still affect the distribution system adversely.

(iv) Mechanical or Electrical Failure: The failure of a source mechanical or electrical component may impair the safety function of another component or system (e.g., the failure of a valve in a non-safety water distribution system causing flooding that short circuits a safety-class electrical motor).

The preliminary performance category of each component of the facility, as determined in Steps 4 and 5 (Subsections 3.5 and 3.6), must be modified to account for the above system interaction effects, using the guidelines provided in Subsection 2.5.

Paragraph (b) of Subsection 2.5 provides the general requirements for precluding interaction that can occur before the source fails or reaches its acceptable behavior limits. Paragraph 2.5(c) provides two options to meet the requirements for precluding adverse interaction that can occur only when the source fails. The following paragraphs provide additional discussions of these two options.

(a) The first criterion in Paragraph (c)(i) of Subsection 2.5 is the more conservative of the two options, because it imposes additional NPH requirements if the failure potential of the target, given the failure of the source, is high. But it can also be more costly, since it may require upgrading the source SSC to the higher performance category of the target. Hence, this criterion should be used when:

(i) upgrading of the source does not involve a significant design change, or

(ii) the existing source design has an adequate margin to withstand the same NPH level as the target.

(iii) The second option given in Paragraph (c)(ii) of Subsection 2.5 requires taking measures to preclude interaction, e.g., by the use of a barrier to prevent the source from interacting with the potential target. Very often this can be the most practical and cost-effective option. The barrier must be placed in the same performance category as the target and be designed to withstand the interaction effects from the source, in addition to the NPH loads.

3.9 Examples of Categorization Using System Interaction Rules

This subsection provides a few examples of the application of categorization rules considering system interaction effects, as provided in Subsection 2.5.

(a) <u>Example 1</u>

Consider an emergency diesel generator in a Hazard Category I facility that has been classified as a "safety-significant" system using DOE-STD-3009-94 guidelines. Assume that the diesel generator and all the support systems (e.g., fuel, lubrication, cooling water, and DC power systems) that perform a safety function have been assigned to NPH Performance Category 2 (PC-2), in accordance with the provisions of Section 2 of this standard.

Now, consider a fluorescent light fixture (source) hung directly above the diesel generator (target). For this case, assume that the light is not needed for required operator actions following an NPH event. Hence the preliminary performance category for the light fixture is PC-1. Diesels themselves are fairly rugged, and a lightweight falling object, like the light fixture, is unlikely to damage them. However, there are some possible weak spots, particularly in the peripheral support systems (e.g., lubrication lines), that might be damaged and result in system failure. Assume that, in accordance with Section 3.7 of this standard, the failure potential of the diesel resulting from the failing light fixture is assessed to be high. (This assessment assumes the lighting fixture will fall during an NPH event, and no credit is taken at this stage for its design strength, if any, against NPH events.) Following Paragraph (c)(i) of Subsection 2.5 of this standard, the lighting fixture should then be placed in NPH Performance Category 2 (PC-2).

(b) <u>Example 2</u>

Consider a case in which batteries for an uninterruptible power supply (UPS) in a Hazard Category 3 facility are in the same room with a 2000-gallon water storage tank. The UPS is classified as a safety system, but the water storage tank is not. Assume that the UPS batteries (and their rack, connections, and the surrounding room structure) have been assigned to NPH Performance Category 2, in accordance with the provisions of Section 2.5 of this standard. Initially, the water storage tank might be considered as NPH Performance Category I (i.e., preliminary performance category). However, a systems interaction check discloses that UPS batteries will short out during water immersion if only 1000 gallons of water flood the room. Thus, in accordance with the criterion given in Paragraph (a)(i) of Subsection 2.5 of this standard, the 2000-gallon tank should have the same NPH performance category as the UPS batteries, that is, PC-2.

But what if the water were stored instead in ten 200-gallon tanks? The individual failure of each tank would not cause the UPS to fail. However, if "multiple common-cause failure" is considered, one could reason that all ten tanks would be affected in the same way by the NPH (an earthquake in this case), and simultaneous failure of several tanks might occur, leading to flooding of the batteries. Thus, each 200-gallon tank should also be placed in NPH Performance Category 2, in accordance with the provisions of Subsections 2.3(c) and 2.5 of this standard.

(c) Example 3

Consider a 100-foot tall laundry building smoke stack at a DOE site that is not part of any safety system. However, its failure (from winds or earthquakes) would be costly and could injure workers, so assume that initially it was classified as NPH Performance Category 1. Consider that there is a single PC-2 safety system component (say an outside pump) that is 50 feet from the base of the stack. Assume that a systems interaction analysis showed that the stack would fail during a seismic event and fall in essentially one piece and would cause the pump to fail if it hits it. But the stack is equally probable to fall in any radial direction, and the target size of the pump is small, fitting into a 2 degree angle. It is concluded that the potential for interaction is low. Thus, in accordance with Paragraph (c)(ii) of Subsection 2.5 of this standard, the stack can be retained in PC-1.

(d) Example 4

Consider a Hazard Category I facility that relies heavily on operator actions, rather than seismically-qualified instrumentation and automatic control systems, to maintain a safe state following a design basis earthquake. Assume that, according io Section 2.5 of this standard, safety system SSCs of this facility have been placed in PC-4. In addition, SSCs needed to permit required operator actions following a design basis earthquake must also be classified as PC-4 (see Paragraph b, Subsection 2.3).

As an example, assume that one earthquake procedure written for this facility requires an operator to go inside the pump room to read a water level gauge (which is seismically qualified) and then relay this information to the control room via a system of walkie-talkies (assume that inside telephone lines are not seismically qualified). Items needed to permit this action, and which must therefore meet NPH Performance Category 4 criteria, include all access doors (deformations of the door frames may be critical), emergency lighting and communication systems (the storage of flashlights and walkie-talkies could become an NPH design consideration), and any water or steam lines whose seismic failure would be hazardous to the operator.

3.10 Preparation of the Final NPH Performance Category List

After the NPH performance categorization has been performed as outlined above, the resulting documentation should be catalogued, numbered, design reviewed, and entered into the document control process so that the quality assurance and applicable independent peer review requirements are satisfied. The results of the categorization should then be recorded in a component performance category list.

In this list, components of a facility should be listed system-by-system and then category-by-category (except PC-0 components). Both the component name and a unique component number should be listed, along with the identification of the reference document which provides the categorization rationale. If a component is part of more than one system, a note should be provided at the bottom of the table identifying the other systems of which it is a part. The list should also indicate the component function number, signifying the criterion that was the basis for selecting the performance category.

As discussed in Subsection 3.6, it is recommended that, when many non-safety components belonging to one performance category can be lumped into one group based on common NPH-related characteristics or location, they be entered into this list with a single entry, unless any such component performs a unique mission-important function.

The final list should be design reviewed and entered into the document control process as a controlled design document with the appropriate revision number. This list should be a living document and should be updated periodically to reflect changes in the plant design that would potentially change the component performance categories. All such changes should be coordinated and approved by the facility Performance Categorization Engineer.

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CONCLUDING MATERIAL

Review Activities:
DOE
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Field Offices
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Preparing Activity:
DOE-EH-53

Project Number:
FACR-0010