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Procedure for Prioritization of Natural Phenomena Hazards Evaluations for Existing DOE Facilities

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Abstract: This document describes the procedure to be used for the prioritization for natural phenomena hazards evaluations of existing DOE facilities in conformance with DOE Order 5480.28, "Natural Phenomena Hazards Mitigation."

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1.0 INTRODUCTION

Natural phenomena hazards (NPH) are unexpected acts of nature which pose a threat or danger to workers, the public or to the environment by potential damage to structures, systems and components (SSCs). Earthquakes, extreme winds (hurricane and tornado), flood, volcanic eruption, lightning strike, or extreme cold or heat are examples of NPH.

It is the policy of the U.S. Department of Energy (DOE) to design, construct and operate DOE facilities so that workers, the public and the environment are protected from NPH and other hazards. During 1993 the DOE Richland Operations Office (RL) transmitted DOE Order 5480.28, "Natural Phenomena Hazards Mitigation," to Westinghouse Hanford Company (WHC) for compliance. The Order includes stringent new NPH criteria for the design of new DOE facilities and the evaluation and upgrade of existing DOE facilities. Criteria and requirements are contained in the Order and in five applicable standards. The last of these standards was released in fiscal year (FY) 1996.

The Order becomes immediately enforceable for new SSCs thirty days following an in-force date to be established by RL. The Order also requires that commitments addressing existing SSCs be included in an Implementation Plan due one year following the in-force date.

In 1995 DOE issued Order 420.1, "Facility Safety." This order contains the same NPH requirements and invokes the same applicable standards as Order 5480.28. It will supersede Order 5480.28 when an in-force date for this order is established through contract revision.

1.1 PHASED APPROACH

WHC is implementing a phased and graded approach for compliance with the Order. Activities will be planned and accomplished in four phases, namely:

- Mobilization, and NPH structural design criteria development for new and existing facilities.
- Prioritization of existing facilities; issuance of the 5480.28 implementation plan; compliance for new facilities.
- Evaluation for NPH vulnerability of the most important existing facilities.
- Upgrade of facilities, if necessary, when justified by a risk benefit analysis.

Mobilization began in the fall of 1993. While awaiting completion of the applicable standards, WHC initiated a program of NPH awareness to alert the WHC staff of the pending compliance requirements of DOE Order 5480.28. Presentations were made throughout the site to WHC projects and programs, the WHC Operations Excellence Council, and to staff from RL. Articles in the Hanford Reach discussed the potential impact of the Order. This period also

saw the development of agreements and understandings on NPH mitigation. The more important of these were:

- The concurrence of RL on an interpretation of new versus existing facilities (Wise).
- A proposed correlation between WHC safety class and NPH performance category (Webb, Conrads).

In October 1995 the last applicable standard, DOE-STD-1023-95, was issued over the Internet and it became evident the Order would soon be effective. Since the Order will become immediately in-force for new SSCs, efforts were concentrated on development of structural design and evaluation criteria to replace the canceled DOE Order 6430.1A and the site design criteria embodied in the Hanford Plant Standards - Standard Design Criteria SDC-4.1. In addition to criteria development, the following plans, studies and procedures have been or will be issued during the Mobilization phase, namely:

- Probabilistic NPH assessment, characterization and criteria for the Hanford site (Tallman 1 and 2, and Conrads 2).
- NPH detection plans for the seismic monitoring of the Hanford site (Reidel, Moore).
- Structural design and evaluation criteria (Conrads 3 and 4) including NPH loads to replace SDC-4.1 of the discontinued Hanford Plant Standards.
- A procedure for prioritization of NPH evaluations for existing DOE facilities (this document).

WHC is proceeding with implementation of the Order and is at the end of the Mobilization phase.

The Prioritization phase will start with the effective date for the Order. At that time the Order is enforceable for the design of all new SSCs. During the Prioritization phase, all existing DOE facilities at the Hanford will be ranked in terms of their importance and NPH vulnerability. Based on this ranking, a prioritized schedule for the NPH evaluation of existing buildings and structures will be included in an Implementation Plan to be submitted to the DOE for approval within one year of the in-force date of the Order. The Implementation Plan will contain NPH evaluation commitments as well as the overall strategy for implementing DOE Order 5480.28 and meeting nuclear safety requirements.

The Implementation Plan will be updated every year there-after until full compliance with the Order is achieved.

1.2 GRADED APPROACH

10 CFR Part 830.3 defines a graded approach as "a process by which the level of analysis, documentation, and actions necessary to comply with a requirement ... are commensurate with the following:

- (1) the relative importance to safety, safeguards, and security [risk];
- (2) the magnitude of any hazard involved;
- (3) the life cycle stage of a facility;
- (4) the programmatic mission of a facility;
- (5) the particular characteristics of a facility; and,
- (6) any other relevant factor."

DOE Order 5480.28 requires that planned activities as well as the level of depth, rigor and thoroughness in accomplishing them, are determined by applying a graded approach. Requirements governing this graded approach are contained in DOE Order 5480.28 (paragraphs 10.b and 12), DOE-STD-1021-93 and DOE-STD-1082-94.

The Order establishes five performance categories (PC) for SSCs based on their safety, mission, and cost significance [items (1), (4) and (6) of the definition].

- Safety significance is determined in safety analyses implementing DOE Orders.
- Programmatic importance is judged based on direction received in the Plant Execution Guidance from DOE and/or as identified by the Operations Divisions in conjunction with their DOE counterpart.
- Cost, except for low value and unimportant SSCs, is seldom known during the prioritization phase. Cost becomes a consideration in determining PCs whenever it is known, usually during facility specific evaluations.

Evaluation of the significance of these items depends on an understanding of the hazard, the life cycle, and facility particulars [items (2), (3) and (5) of the definition].

Historically, WHC and predecessor operating contractors at Hanford have classified facilities/SSCs into four safety classes based on their importance to safety. Need for a correlation among these overlapping classifications and also with hazard categories was recognized early-on. In response, a consensus position evolved that expands the methodology of DOE-STD-1021-94 and defines an appropriate correlation of PCs to the existing process of SSC safety designation used by WHC. The proposed correlation shown in Table 1.0 is the basis of the graded approach used to implement DOE Order 5480.28. Development of the correlation is described in WHC-SD-GN-RD-30011 (Webb, Conrads).

Facility Type	Reactor or PSD-designated	Hazardous or essential non-reactor facility				General use	No safety function
Hazard Category	HC-1	HC-2		HC-3	Radiological		
Hazard Class			High (HH)	Moderate (MH)	Low (LH)		
Safety Importance	Safety Class		Safety Significant				
	Performs or preserves reactor safety function	Prevents or mitigates unacceptable radiological risk to: Offsite public	Defense in depth. Prevents or mitigates unacceptable risk to:		Worker safety. Prevents or mitigates serious injury not controlled by ISP to:	Occupant & worker safety controlled by building code and ISP	
			Offsite public	Onsite worker			
	SC-1			SC-2	SC-3	Non-Safety Class	
	Mission Importance Criteria TBD				Historic or UBC essential	Not essential	None
Cost Importance	Cost Importance Criteria TBD						None
Performance Category	PC-4	PC-3		PC-2	PC-1		PC-0
	PG 1X10 ⁻⁵	PG 1X10 ⁻⁴		PG 5X10 ⁻⁴	PG 1X10 ⁻³		No PG

Table 1.0 GRADED APPROACH and PERFORMANCE CATEGORIZATION

Note: DOE Program Secretarial Officer (PSO) may designate a facility to a higher Performance Category. Hazard Category (HC) for nuclear facilities per DOE Order 5480.23 drives the level and rigor of FSAR analysis and its references. High, medium and low Hazard Class (HH, MH & LH) for non-nuclear facilities per DOE Order 5481.18. Safety Class and Safety Significant classification per WHC-CM-4-46 Rev 2, chapter 9.0. Institutional Safety Program (ISP) per DOE Order 5480.23. Obsolete Westinghouse Hanford Company (WHC) safety class (SC) per WHC-CM-4-46 Rev 1, chapter 9.0. These designations no longer apply, but are still contained in existing SELs and reference documentation until they can be revised. Performance Category (PC) and performance goal per DOE Order 5480.28 and DOE-STO-1020. Performance goal (PG) is mean annual probability of exceedance of acceptable behavior limits for the PC.

1.3 PRIORITIZATION REQUIREMENTS

The large inventory of existing buildings and structures at the Hanford Site precludes their simultaneous evaluation for NPH effects. As part of the graded approach, prioritization ranks existing buildings and structures for the purpose of allocating resources to those most important and vulnerable. The process results in a prioritized schedule in compliance with DOE Order 5480.28 listing buildings and structures for possible future NPH evaluation. This section reviews the requirements governing prioritization.

Guidance on the minimum goals of prioritization are contained in DOE-STD-1082, namely:

- give primary attention to controlling and reducing risks to the public, the environment, and the workers to acceptable levels,
- consider available information from safety analyses and other sources and use a graded approach to the acquisition of new data,
- address programmatic constraints of time, funding, and mission when developing schedules,
- accommodate changes at later dates.

Specific requirements governing prioritization contained in paragraph 11.a(5) of DOE Order 5480.28 are:

- screen and rapidly identify sites of greatest vulnerability to NPH effects,
- direct initial efforts to existing buildings and structures which are of greatest importance in terms of safety, mission, and costs,
- eliminate from further consideration existing buildings and structures with low probability of NPH vulnerability due to their inherent ruggedness or benign site conditions.

NPH prioritization puts a higher priority on life safety and provides a finer ranking of existing buildings and structures than found in the five performance categories shown in Table 1.0. The four step prioritization procedure described in this document is an outgrowth of a process (Conrads 1) developed with the consultation and cooperation of the Westinghouse GOCO (government-owned, contractor-operated) sites.

The process of prioritizing existing buildings and structures for future NPH evaluation will be accomplished during the Prioritization phase of implementation. A worksheet (Table 2.0, shown on next page) will be completed by the facility manager for each existing building and structure on the Hanford site under the management and control of WHC, ICF/KH and BCSR. The four step procedure to be used in completing the worksheet is described in the following sections.

Table 2.0 NATURAL PHENOMENA HAZARDS PRIORITIZATION WORKSHEET

BUILDING/STRUCTURE	Name:	Number:
Floor Area (sm):	Location:	Program:

SCREENING	NO	YES	IF YES, EXPLAIN
Any hazardous materials?			Type Material.... Hazard Category.. WHC Safety Class.. SAR Document No..
Any permanent occupants?			Remaining Life for facility..
Any present or future mission?			Importance to program.....
Any intent to restore or replace in event of NPH damage?			Estimated cost to restore/replace > \$10,000,000 < \$10,000,000

IF ALL ANSWERS ARE "NO", FACILITY IS UNIMPORTANT. MARK BOX PC-0 & STOP.

IF ANY ANSWER IS "YES", FACILITY IS IMPORTANT. CONTINUE & COMPLETE PRIORITIZATION WORKSHEET.

PRIORITIZATION		DATA	RATING	SCORE
Performance Category	Circle applicable boxes on PERFORMANCE CATEGORIZATION worksheet (table 7-1). Circled box furthest to left determines PC designation. Attach table.		PC designation:	
Building Occupancy	Day shift workers..... Visitors and others.....		Max occupancy:	
Facility Condition	Year built..... Type construction..... Serious structural accidents? ATC-21 rating.....		POOR MARGINAL GOOD LIKE NEW	
Existing NPH Analyses	Document Number..... Date of Document..... Building Code used..... Date of Code.....		POOR MARGINAL VERIFIABLE ACCEPTABLE	
PRIORITY FOR NPH EVALUATION (equals the sum of the scores).....				

MANAGER APPROVAL	Signature:	Date:
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2.0 STEP 1: SCREEN SITES FOR NPH VULNERABILITY

The first step in the prioritization process is determination of the magnitude of the NPH and the identification of sites and areas of greatest vulnerability to NPH effects. Probabilistic NPH assessments and characterization of each site must be completed early-on. Based on the NPH characterization criteria developed, sites and areas of no, or low, NPH risk can be eliminated from further consideration.

NPH are external to a site and at Hanford include earthquake, wind/tornado, flood, volcanic ashfall, and lightning. New, stringent requirements governing the assessment and characterization of NPH are contained in DOE Order 5480.28 (paragraph 10.c), DOE-STD-1022-94 and DOE-STD-1023-95. Site specific NPH assessments have been completed for the Hanford. Based on these assessments, NPH characterization criteria were developed and are documented in:

- Tallman-1, A. M., WHC-SD-W236A-TI-002 Rev 1, "Probabilistic Seismic Hazard Analyses, DOE Hanford Site, Washington" (March 14, 1996).
- Tallman-2, A. M., WHC-SD-GN-ER-501 Rev 0, "Natural Phenomena Hazards, Hanford Site, South-Central Washington" (April 16, 1996).
- Conrads-2, T.J., WHC-SD-GN-ER-30038 Rev 0, "Volcanic Ashfall Loads for the Hanford Site" (April 4, 1996).

These documents indicate a higher level of NPH risk than shown in earlier Hanford design criteria. Facilities/SSCs built to previous Hanford design criteria met previous criteria, usually with a generous margin of safety. However, because of the new criteria, existing facilities/SSCs may be considered at risk until they are evaluated in accordance with the current NPH criteria contained in DOE-STD-1020 and WHC-SP-1174 (Conrads-4).

Based on the NPH characterization criteria, no area within the Hanford Site can be simply eliminated from further consideration because of no, or low, NPH risk. Except for flood, all areas within the Hanford Site have relatively the same vulnerability to NPH effects.

Step 1 has been completed for the Hanford site.

3.0 STEP 2: SCREEN OUT UNIMPORTANT BUILDINGS AND STRUCTURES

The next step in prioritization is to identify unimportant existing buildings and structures, document the process, and then eliminate them from further consideration.

Unimportant buildings and structures are designated Performance Category "0" (PC-0) and do not require NPH qualification or mitigation. These are defined as non-hazardous, unoccupied, low value and non-essential buildings and structures where NPH are not an issue. PC-0 buildings and structures must meet all of the following unimportance criteria:

- no hazardous material and
- no permanent occupants and
- no present or future mission and
- no intent to restore or replace.

Examples are: an unused guardhouse awaiting a decision on deactivation, a deactivated substation visited on a regular basis only by security, and structures currently being deactivated or decommissioned.

Notice, as shown in Table 1.0, PC-0 is a more limited application than the obsolete non-safety class (sometimes called SC-4) designation which included both PC-1 and PC-0. NPH and other structural design and evaluation criteria only apply to PC-0 SSCs in "3-over-1" situations. That is when failure or damage to a PC-0 SSC in an accident or NPH event could jeopardize a higher PC level SSC, the criteria governing the higher level PC is used for the design evaluation of the PC-0 SSC.

4.0 STEP 3: PRIORITIZE IMPORTANT BUILDINGS AND STRUCTURES

Existing buildings and structures not designated PC-0, are important and are prioritized for evaluation based on these four priority factors:

- Performance Category
- Occupancy Considerations
- Facility Condition
- Existing Analysis

For each priority factor, a building or structure is given a numerical score (0 to 10). Unweighted scores are added to generate the total score. Higher scores signify a higher priority for possible future NPH evaluation.

4.1 PERFORMANCE CATEGORIES

DOE Order 5480.28 requires that, for the purposes of NPH design and evaluation, facilities/SSCs be placed in one of five performance categories. Performance categories are established for facilities/SSCs on the basis of their safety, mission and cost significance. Performance categories are the basis for the graded approach as discussed in Section 1.3.

Performance categorization is considered appropriate for scaling the potential impact of an NPH event on an existing building or structure. Prioritization scores for the potential building/structure hazard are assigned based on the Performance Category as follows:

<u>Performance Category</u>	<u>Score</u>
PC-4	10
PC-3	5
PC-2	3
PC-1	1
PC-0	0

4.2 OCCUPANT CONSIDERATIONS

The higher performance categories (PC-4, PC-3 and PC-2) are mostly concerned with the risks to the off-site population and to on-site persons. For example, PUREX would probably be designated as a PC-3 building, whereas an office building is typically designated to be a PC-1 structure. Occupancy considerations in this prioritization process emphasize the life-safety of workers, visitors and possibly other occupants of a building.

The occupancy loading of a building is representative of the relative risk to building occupants due to structural failure or collapse during or after a NPH event. Occupancy is taken as the number of people continuously occupying the building for more than two hours.

Prioritization scores are assigned based on the maximum allowed building occupancy, that is the sum of the normal shift staff plus visitors in conference rooms, auditoriums, etc.

<u>Occupancy</u>	<u>Score</u>
>100	10
10-99	5
1-9	1
0	0

4.3 FACILITY CONDITION

Facility condition encompasses the design capacity of the facility for NPH loads, and any degradation of the structure or the foundation that may have reduced that capacity. Unlike fine wines, buildings and structures normally deteriorate with age or are modified to accommodate a new mission. The rate of deterioration is a function of the maintenance program and any unusual historical structural incidents, such as accidents, restorations and modifications. With nominal maintenance and no major structural incident, and for the purpose of prioritization for NPH evaluation, the facility can be assumed to deteriorate as follows:

- First 5 years, facility condition should be considered like new.
- Next 10 years, facility condition should be considered good.
- Next 15 years, facility condition should be considered marginal.
- After 25 years, facility condition should be considered poor.

If the facility has experienced a serious structural accident or major modification, the above deterioration schedule may not be conservative. In this case a field walk-down to determine the facility condition is indicated. A widely recognized methodology has been developed by the Applied Technology Council (ATC) and endorsed by the Federal Emergency Management Agency (FEMA). This approach is set forth in:

- Applied Technology Council, "Rapid Visual Screening of Buildings for Potential Seismic Hazards", (ATC-21, also issued by the Federal Emergency Management Agency as FEMA 155, July 1988).

The procedure is a ranking process to develop the relative capacity of

structures to prioritize their detailed evaluation or to determine if detailed evaluation is even necessary. A primary evaluation criteria under this methodology is based on the type of structure. The more common structural types are listed below:

- Wood frame
- Steel moment resisting frame
- Braced steel frame
- Steel Frame with concrete shear wall
- Reinforced concrete moment resisting frame

The historical performance of these and other types of structures is known and includes assessment of degradation mechanisms, such as rusting of structural steel frames, mortar degradation in masonry structures, wood rot, etc. This methodology assigns a rating based on the sum of values assigned to evaluation attributes. The higher the ATC rating, the greater the potential seismic and other NPH resistance.

Prioritization scores for the facility condition are assigned based on facility age when there has been no serious structural accident. If there has been a serious structural accident, then the prioritization score should be based on the ATC-21 ratings. If that is not feasible, a prioritization score of 10 should be assigned. The schedule for scoring is as follows:

<u>Facility Age</u>	<u>ATC-21 Rating</u>	<u>Facility Condition</u>	<u>Score</u>
<3 years	>3	Poor	10
4-10	3-0	Marginal	5
11-20	<0	Good	1
>20		Like new	0

4.4 EXISTING ANALYSIS

The methodology of NPH evaluation, especially for seismic loads, has evolved significantly over the past 20 years. Consequently, the quality of an evaluation of a structure's capability to adequately resist NPH loads is largely a function of its age. Other important quality considerations are whether the evaluation uses the correct NPH criteria and codes, and has been or can be verified. A four tier classification is used to describe the quality of NPH structural documentation, namely:

- **Poor:** Documentation has not been found or is greater than 20 years old. The twenty years old analysis restriction is based on the issuance of the 1976 Uniform Building Code (UBC) wherein unified seismic analysis methodology was promulgated.
- **Marginal:** Documentation exists and is dated after 1976. Such analyses may, or may not, comply with NPH requirements found in DOE-STD-1020 and WHC-SP-1174 (Conrads-4).
- **Verified:** Documentation exists, was performed after 1990 and has been verified by an external review. UCRL-15910 was issued 6-90 and contained the mandatory NPH methodology and a graded approach upon which DOE-STD-1020 and DOE Order 5490.28 are built. These quality evaluations approach compliance with NPH requirements of WHC-SP-1174 (Conrads-4).
- **Acceptable:** Documentation exists and is supported by retrievable verifiable calculations that comply with NPH requirements in DOE-STD-1020 and WHC-SP-1174 (Conrads-4). Such an evaluation was performed to currently acceptable methods, acceptable NPH levels (current seismic response spectra, ANSI or equivalent wind speeds, etc.) and consensus codes (ASME, AISC, ACI, etc.).

Care should be taken that the entire structure and foundation have been adequately evaluated. Where several NPH structural and geotechnical reports exist, the documentation classification should reflect the quality of the least adequate of the necessary evaluations.

The condition of documentation is important mainly for the higher performance categories, PC-4, PC-3 and PC-2. External review (e.g., DOE, DNFSB) of NPH designs and evaluations is typically performed only on the higher performance category facilities/SSCs. On the other hand, analyses for PC-1 facilities/SSCs can be assumed to acceptable based on the completion of construction in accordance with the UBC.

Prioritization scores for existing analyses are assigned based on the quality of documentation and on the performance category as follows:

Documentation Quality	PC-3,4	PC-2	PC-1
Poor	10	5	0
Marginal	5	3	0
Verified	1	1	0
Acceptable	0	0	0

5.0 STEP 4: ELIMINATION OF INHERENTLY RUGGED BUILDINGS AND STRUCTURES

The final step in the prioritization process is described in paragraph 11.a(5) of DOE Order 5480.28:

"Areas where SSCs might not be vulnerable to NPH effects due to inherent ruggedness or benign site conditions can be identified and eliminated from further consideration."

The approach used in this procedure is to identify a conservative cut-off value of the prioritization score that separates inherently rugged buildings and structures from less rugged facilities requiring NPH evaluation.

To be inherently rugged the facility condition must be "good" or "like new", and the existing analyses must be "verifiable" or "acceptable". Also to be conservative, the building occupancy should be 9 persons or less. The maximum and minimum prioritization scores considering these restraints are shown in Table 3.0.

CUT-OFF SCORES	PC-4	PC-3	PC-2	PC-1
Performance Category	10	5	3	1
Building Occupancy	n/a (10 exceeds limit)	0	Pick 2 (not 3)	1
Facility Condition		0		1
Existing Analysis		0		0
RUGGED RANGE	None	5	5 to 3	3 to 1
FULL RANGE	40 to 10	35 to 5	28 to 3	21 to 1

Table 3.0 Prioritization Scores for Inherently Rugged Facilities

Five (5) is the cut-off prioritization score selected to eliminate inherently rugged buildings and structures. No PC-4 facilities are eliminated from evaluation since the minimum score is 10. A PC-3 facility must be unoccupied, like new, and with acceptable documentation to be eliminated. For a PC-2 facility to have a score of 5 or less, it must be either unoccupied, like new or have acceptable documentation. Because the scores for both building occupancy and facility condition go 0, 1, 5, 10; only PC-1 facilities with scores of "1" for these prioritization factors can only be eliminated.

It is the intent of this prioritization process to identify buildings and structures with scores of 5 or less as inherently rugged, and to eliminate them from further NPH consideration. Since this is the stated intent of DOE Order 5480.28, no waiver will be requested or needed.

6.0 REFERENCE DOCUMENTS

6.1 Requirement Documents

10 CFR Part 830, "Nuclear Safety Management", Code of Federal Regulations

DOE Order 420.1, "Facility Safety" (1995), U.S. Department of Energy, Washington, DC

DOE Order 5480.28, "Natural Phenomena Hazards Mitigation" (1-15-93), U.S. Department of Energy, Washington, DC

DOE Order 6430.1A, "General Design Criteria" (4-6-89), U.S. Department of Energy, Washington, DC

DOE-STD-1020-94, "Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities" (April 1994), U.S. Department of Energy, Washington, DC

DOE-STD-1021-93, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components" (July 1993), U.S. Department of Energy, Washington, DC

DOE-STD-1022-94, "Natural Phenomena Hazards Site Characterization Criteria" (March 1994), U.S. Department of Energy, Washington, DC

DOE-STD-1023-95, "Natural Phenomena Hazards Assessment Criteria" (September 1995), U.S. Department of Energy, Washington, DC

DOE-STD-1082-94, "Preparation, Review, and Approval of Implementation Plans for Nuclear Safety Requirements" (October 1994), U.S. Department of Energy, Washington, DC

Hanford Plant Standards, SDC 4.1 Rev 11, "Design Loads" (1994), DOE Richland Operations, Richland WA

UBC, "Uniform Building Code" (1976), International Conference of Building Officials, Whittier, CA.

UCRL-15910, "Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards" (6-90). UCRL-15910 is now superseded by DOE Order 5480.28.

6.2 Other Documents

Applied Technology Council, "Rapid Visual Screening of Buildings for Potential Seismic Hazards", (ATC-21, also issued by the Federal Emergency Management Agency as FEMA 155, July 1988), Applied Technology Council, Redwood City CA

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