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Cold Vacuum Drying System Natural Phenomena Hazards

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Abstract: This document specifies the natural phenomena design loads for the Cold Vacuum Drying System.

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**COLD VACUUM DRYING SYSTEM
NATURAL PHENOMENA HAZARDS**

**WHC-SD-SNF-DB-010
Revision 0**

June 1996

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LIST OF TERMS

BP	before present
CVDS	Cold Vacuum Drying System
DOE	U.S. Department of Energy
NPH	natural phenomena hazard
NRC	U.S. Nuclear Regulatory Commission
PMP	probable maximum precipitation
Supply System	Washington Public Power Supply System
WNP-2	Washington Public Power Supply System Nuclear Plant 2

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COLD VACUUM DRYING SYSTEM NATURAL PHENOMENA HAZARDS

1.0 INTRODUCTION

This document specifies natural phenomena hazard (NPH) loads for use in the design and construction of the Cold Vacuum Drying System (CVDS), a facility that will be located in the 100 K Area of the Hanford Site (Figure 1). U.S. Department of Energy (DOE) requirements governing the derivation and mitigation of NPH loads are found in DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, and its supporting standards: DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*; DOE-STD-1022-94, *Natural Phenomena Hazards Site Characteristics Criteria*; and DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria*. DOE Order 5480.28 requires that each structure, system, and component be assigned to one of five performance categories based on safety class and hazard category. Each performance category has an associated NPH goal that serves as a measure of the level of protection required against potential natural phenomena. The CVDS facility has been designated a Performance Category 3 facility (WHC 1996).

DOE regulatory policy for the design and construction of the CVDS requires a level of nuclear safety comparable to that of U.S. Nuclear Regulatory Commission (NRC) licensed facilities (Grumbly 1995). The NRC requirements appropriate for deriving NPH loads for the CVDS are found in Title 10, *Code of Federal Regulations*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste" (10 CFR 72). With the exception of earthquake-induced ground motion, the compliance to both NRC and DOE requirements is accomplished by using the more stringent of the requirements for the design. The NPH design loads for the CVDS facility are summarized in Table 1. The remainder of this document provides more detail on NPH loads and reviews the derivation of these loads.

2.0 SEISMIC CRITERIA

2.1 BACKGROUND

A comparison of the NRC and DOE seismic design requirements and a discussion of the CVDS facility's seismic design strategy are presented in WHC-SD-SNF-DB-004, *Spent Nuclear Fuel Project Seismic Design Criteria, Nuclear Regulatory Commission Equivalency Evaluation Report* (WHC 1996), and are not repeated here. The DOE seismic design requirements are being used for the CVDS facility. The seismic characteristics and hazard assessment of the Hanford Site are discussed in WHC-SD-W236A-TI-002, *Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington* (Geomatrix 1996).

Figure 1. Location of the Cold Vacuum Drying System.

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Table 1. Natural Phenomena Design Loads for the Cold Vacuum Drying System.

Hazard	Load	Application documents
Seismic	Performance Category 3 (0.26 g) equal hazard response spectra ^a	DOE Order 5480.28 ^b DOE Standard 1020-94 ^c Table 2 and Figure 1
Straight wind	129 km/h (80 mi/h), fastest mile at 9 m (30 ft)	ASCE-7 ^d DOE Standard 1020-94 (including missiles) ^e
Tornado	Wind speeds 322 km/h (200 mi/h) total 257 km/h (160 mi/h) rotational 64 km/h (40 mi/h) translational	NRC Standard Review Plan ^f 3.3.2 Tornado Loading
Volcanic ash	117 kg/m ² (24 lb/ft ²) ground ash load	NRC Standard Review Plan ^f 3.8.4 Other Seismic Category Structures
Flooding	Columbia River: 140 m (460 ft) above mean sea level Site drainage basin: 19 cm (7.4 in.) for 6-hour probable maximum precipitation Site drainage: 23 cm (9.2 in.) for 6-hour probable maximum precipitation	ANSI/ANS-2.8-1992 ^g NRC Regulatory Guide 1.59 ^h NRC Standard Review Plan ^f 2.4.2 Floods
Lightning	Lightning protection shall be considered for facility.	NFPA 780 ⁱ
Snow	98 kg/m ² (20 lb/ft ²) ground load	ASCE-7 ^d

Note: Missiles are considered to strike surfaces in any direction, and the vertical velocities are 70% of the horizontal velocities except for the 1-in steel rod, which has the same velocity in any direction. The utility pole and automobile are considered to strike surfaces up to maximum of 9.1 m (30 ft) above the highest finished grade within 0.8 km (0.5 mi) of the plant. The other missiles can strike at any elevation. These criteria are based on recent revision of the WNP-2 tornado criteria by NRC:

- Parrish, J. V., 1995, WNP-2, Operating License NPF-21, Request for Approval to Revise Tornado Design Criteria, (letter 602-95-212 to U.S. Nuclear Regulatory Commission, October 10), Washington Public Power Supply System, Richland, Washington.
- Clifford, J. W., 1996, Revision of Tornado Design Criteria for the Washington Public Power Supply System (WPPSS) Nuclear Project No. 2 (WNP-2) (TAC No. 88626) (letter G12-96-032 to J. V. Parrish, Washington Public Power Supply System, January 24), U.S. Regulatory Commission, Washington, D.C.

^aGeomatrix, 1996, Probabilistic Seismic Hazard Analysis DOE Hanford Site, Washington, WHC-SD-W236A-TI-002, Rev. 1, prepared by Geomatrix Consultants, Incorporated, for Westinghouse Hanford Company, Richland, Washington.

^bDOE Order 5480.28, Natural Phenomena Hazards Mitigation, U.S. Department of Energy, Washington, D.C.

^cDOE Standard 1020-94, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, U.S. Department of Energy, Washington, D.C.

^dASCE, 1993, Minimum Design Loads for Building and Other Structures, ASCE-7, American Society of Civil Engineers, New York, New York.

^eNRC, 1981, Standard Review Plan, NUREG-0800, U.S. Nuclear Regulatory Commission, Washington, D.C.

^fANSI/ANS, 1992, Determining Design Basis Flooding at Power Reactor Sites, ANSI/ANS-2.8-1992, American Nuclear Society, La Grange Park, Illinois.

^gNRC, 1977, Design Basis Floods for Nuclear Power Plants, Regulatory Guide 1.59, U.S. Nuclear Regulatory Commission, Washington, D.C.

^hNFPA, 1992, Lightning Protection, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

2.2 U.S. DEPARTMENT OF ENERGY DESIGN REQUIREMENTS

Seismic design for Performance Category 3 projects shall follow, as a minimum, DOE Order 5480.28 and supporting standard DOE-STD-1020-94, Chapter 2 and Appendix C. Equal-hazard 5% damped horizontal and vertical response spectra anchored at 0.26 g horizontal are shown in Figure 2. Table 2 provides spectral values for the various damping values that may be required for design. In-structure response spectra need to be generated for structures, systems, and components supported by the structure. Performance Category 1 and 2 structures, systems, and components shall use the *Uniform Building Code* (ICBO 1991), Zone 2B, as discussed in DOE-STD-1020-94. Use standard occupancy rules for Performance Category 1 and essential facilities rules for Performance Category 2.

3.0 WIND AND TORNADO CRITERIA

3.1 BACKGROUND

The Hanford Site is located in a semiarid region of southeastern Washington. The Cascade Range to the west greatly influences the climate of the Hanford Site by causing a rain shadow effect. This mountain range also serves as a source of cold air drainage, which has considerable effect on the wind regime of the Hanford Site.

Data have been collected since 1945 at the Hanford Meteorological Station, located between the Hanford Site's 200 East and West Areas. This includes wind data from six levels on a 125-m- (410-ft-) high tower. These data are supplemented with data from 26 monitoring stations on and around the Hanford Site. The most recent compilation of these data is in PNL-9809, *Hanford Site Climatological Data Summary 1993 with Historical Data* (Hoitink and Burk 1994).

3.2 U.S. DEPARTMENT OF ENERGY DESIGN REQUIREMENTS

Two probabilistic wind hazard assessments have been completed for the Hanford Site. The first assessment was completed by Lawrence Livermore National Laboratory and reported in UCRL-53526, *Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites* (Coats and Murray 1985). This assessment was based on more than 30 years of pre-1979 Hanford Site wind data. The results are shown in Figure 3 and are the basis for the recommended wind speeds for the Hanford Site listed in DOE-STD-1020-94, Table 3-2. The wind missiles are listed in DOE-STD-1020-94, Table 3-1.

Figure 2. Performance Category 3 Horizontal and Vertical Design Response Spectra with 5% Damping at the Site of the Cold Vacuum Drying System.

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Table 2. Cold Vacuum Drying System Design Response Spectra.

Frequency (Hertz)	Damping					
	0.5%	2%	5%	7%	10%	12%
Horizontal response spectra (g)						
100	0.26	0.26	0.26	0.26	0.26	0.26
33.3	0.26	0.26	0.26	0.26	0.26	0.26
13.3	0.57	0.48	0.41	0.38	0.36	0.35
10	0.77	0.59	0.47	0.43	0.38	0.36
5	1.04	0.76	0.58	0.52	0.45	0.42
3.3	0.98	0.72	0.54	0.48	0.42	0.39
2	0.74	0.55	0.41	0.37	0.33	0.30
1	0.45	0.34	0.26	0.23	0.21	0.19
0.5	0.22	0.17	0.13	0.12	0.11	0.10
0.25	0.08	0.06	0.05	0.05	0.04	0.04
Vertical Response Spectra (g)						
100	0.18	0.18	0.18	0.18	0.18	0.18
50	0.18	0.18	0.18	0.18	0.18	0.18
13.3	0.60	0.46	0.37	0.33	0.30	0.28
10	0.66	0.49	0.37	0.33	0.29	0.27
5	0.60	0.44	0.33	0.30	0.26	0.24
3.3	0.48	0.36	0.27	0.24	0.21	0.19
2	0.32	0.24	0.18	0.16	0.14	0.13
1	0.19	0.14	0.11	0.10	0.09	0.08
0.5	0.14	0.11	0.08	0.07	0.07	0.06
0.25	0.06	0.05	0.04	0.03	0.03	0.03

Figure 3. Straight Wind and Tornado Hazards.

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CVDS

A second study, NUREG/CR-4492, *Methodology for Estimating Extreme Winds for Probabilistic Risk Assessment* (Ramsdell et al. 1986), describes a procedure for estimating extreme wind probabilities. The application of this methodology to Hanford Site data, including post-1979 data, resulted in the hazard curves shown in Figure 3. There are no known local meteorological events or changes in methodology since 1986 that would cause significant changes to the Hanford Site wind hazard.

The wind hazard annual probability of exceedance for Performance Categories 1 and 2 is 2×10^{-2} (DOE-STD-1020-94). On Figure 3, this is about 25 m/s (55 mi/h) on the Coats-and-Murray curve and about 26 m/s (58 mi/h) on the Ramsdell-and-Others curve. However, a minimum design wind speed of 31.3 m/s (70 mi/h) is required by the American Society of Civil Engineers in ASCE-7, *Minimum Design Loads for Building and Other Structures* (ASCE 1993), and recommended by DOE-STD-1020-94. Therefore, the Hanford Site design basis wind speed for Performance Categories 1 and 2 is 31.3 m/s (70 mi/h). All wind speeds are fastest-mile speeds at 9 m (30 ft) off the ground.

The straight wind hazard exceedance probability for Performance Category 3 is 1×10^{-5} . On Figure 3, this is approximately 30 m/s (67 mi/h) on the Coats-and-Murray curve and 32 m/s (72 mi/h) on the Ramsdell-and-Others curve. In DOE-STD-1020-94, the minimum straight wind speed for Performance Category 3 design is 35.8 m/s (80 mi/h), which is higher than either of the wind hazard studies and is, therefore, the design basis for the site. A 6.81-kg (15-lb) timber plank missile, 0.61 m x 1.22 m (2 ft x 4 ft), is applied to Performance Category 3 structures, systems, and components at 22.4 m/s (50 mi/h) to a height of 9 m (30 ft). These wind criteria are higher than the NRC requirements and are applied to the CVDS.

The intersection of the straight wind and tornado hazard curves determines whether tornadoes should be included in the design and evaluation criteria (Coats and Murray 1985). If the exceedance probability at the intersection is less than 2×10^{-5} , straight winds control the design criteria. In Figure 3, this intersection is at 3×10^{-6} (Coats and Murray 1985) and 8×10^{-6} (Ramsdell et al. 1986). Therefore, following DOE guidance, the Hanford Site does not have a DOE design basis tornado.

3.3 U.S. NUCLEAR REGULATORY COMMISSION DESIGN REQUIREMENTS

The guidance in 10 CFR 72 with respect to straight wind and tornado hazard mitigation is very general and nonprescriptive (10 CFR 72.122[b]). The Standard Review Plan section on wind loading (NRC 1981, 3.3.1) is specific and serves as a basis for determining appropriate straight wind and tornado values for the CVDS because it has been accepted by the NRC for issuing the materials licenses for such facilities. The 100-year, fastest-mile wind speed is used for the straight wind calculations using American Society of Civil Engineers methodology (ASCE 1993, ASCE 1961). The 100-year, fastest-mile wind at the Hanford Site is about 105 km/h (65 mi/h) (Figure 3). However, because DOE-STD-1020-94 requires a minimum of 129 km/h (80 mi/h) for Performance Category 3, the higher DOE value will be used for the design of the CVDS.

Washington Public Power Supply System (Supply System) Nuclear Plant 2 (WNP-2), located on property within the boundaries of the Hanford Site, was licensed to use tornado design wind speeds of 483 km/h (300 mi/h) rotational and 97 km/h (60 mi/h) translational, with a pressure drop of 2,109 kg/m² (3 lb/in²) occurring at 703 kg/m²/s (1.0 lb/in²/s). These wind speeds are higher than would be required by Regulatory Guide 1.76, *Design Basis Tornado for Nuclear Power Plants* (NRC 1974). Regulatory Guide 1.76 indicates that the Hanford Site is in tornado Region III for which the criteria are 305 km/h (190 mi/h) rotational and 80 km/h (50 mi/h) translational, with a 1,055 kg/m² (1.5 lb/in²) pressure drop at 422 kg/m²/s (0.6 lb/in²/s). The NRC staff have proposed dividing the United States into two regions and making the total rotational and translation wind speeds for sites west of the Rocky Mountains 322 km/h (200 mi/h) (NRC 1993). The basis for this consideration is a tornado hazards study, NUREG/CR-4461, *Tornado Climatology of the Contiguous United States* (Ramsdell and Andrews 1986). The Supply System requested (Parrish 1995; see Appendix A) a revision of the WNP-2 tornado criteria based upon the NRC staff's proposal for tornado wind speeds west of the Rocky Mountains (NRC 1993) and on the staff's acceptance of the design basis tornado characteristics in NUREG-1503, *Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design* (NRC 1994). The impact velocities for the proposed tornado missile spectrum based on the reduced wind speed of 322 km/h (200 mi/h) were calculated by the Supply System. The NRC accepted the proposed lower tornado missile criteria (Clifford 1996; see Appendix B). The CVDS tornado design requirements, including design missiles, are listed below:

- Wind speed
 - 322 km/h (200 mi/h) total
 - 257 km/h (160 mi/h) rotational
 - 64 km/h (40 mi/h) translational
- Pressure drop
 - 6,205 Pa (0.90 lb/in²) at 2,068 Pa/s (0.30 lb/in²/s)
- Missiles
 - Wood plank
 - 52 kg (115 lb)
 - 0.092 m x 0.289 m x 3.66 m (3.6 in. x 0.94 ft x 12 ft)
 - 49.3 m/s (161.7 ft/s) horizontal impact velocity
 - 6-in. schedule 40 pipe
 - 130 kg (287 lb)
 - 0.168 m diameter x 4.58 m (6.6 in. diameter x 15 ft)
 - 8.2 m/s (27.0 ft/s) horizontal impact velocity
 - 1-in. steel rod
 - 4 kg (8.8 lb)
 - 0.0254 m diameter x 0.915 m (1 in. diameter x 3 ft)
 - 7.6 m/s (24.9 ft/s) horizontal impact velocity

- Utility pole
 - 510 kg (1,124 lb)
 - 0.343 m diameter x 10.68 m (13.5 in. diameter x 35 ft)
 - 9.4 m/s (30.7 ft/s) horizontal impact velocity
- 12-in. schedule 40 pipe
 - 340 kg (750 lb)
 - 0.32 m diameter x 4.58 m (12.75 in. diameter x 15 ft)
 - 6.6 m/s (21.8 ft/s) horizontal impact velocity
- Automobile
 - 1810 kg (3,990 lb)
 - 5 m x 2 m x 1.3 m (16.4 ft x 6.6 ft x 4.3 ft)
 - 32.1 m/s (105.2 ft/s) horizontal impact velocity.

The missiles are considered to strike surfaces in any direction, and the vertical velocities are 70% of the horizontal velocities except for the 1-in. steel rod, which has the same velocity in any direction. The utility pole and automobile are considered to strike surfaces up to a maximum of 9.1 m (30 ft) above the highest finished grade within 0.8 km (0.5 mi) of the plant. The other missiles can strike at any elevation.

4.0 VOLCANIC ASH CRITERIA

4.1 BACKGROUND

Volcanic hazards that have affected the Hanford Site in the past 20 million years are of two types: (1) continental flood basalt volcanism that produced the Columbia River Basalt Group, which underlies the Hanford Site, outcropping in the surrounding ridges; and (2) volcanism associated with the Cascade Range. Several volcanoes in the Cascade Range are currently considered to be active, but activity associated with flood basalt volcanism has ceased.

The flood basalt volcanism that produced the Columbia River Basalt Group occurred between 17 million and 6 million years before present (BP). Most of the lava was extruded during the first 2 to 2.5 million years of the 11-million-year volcanic episode. Volcanic activity has not recurred during the last 6 million years, suggesting cessation of the tectonic processes that created the episode. The recurrence of Columbia River basalt volcanism is not considered to be a credible volcanic hazard (DOE 1988).

The Cascade Range has been volcanically active throughout the Pleistocene epoch (approximately 2 million years BP to 10,000 years BP) and the Holocene epoch (10,000 years BP to present). The eruption history of the Holocene best characterizes the most likely types of activity in the next 100 years. Many of the volcanoes have been active in the last 10,000 years, including Mount Mazama (Crater Lake) and Mount Hood in Oregon, and Mount St. Helens, Mount Adams, and Mount Rainier in Washington. The Hanford Site is approximately 150 km (95 mi) from Mount Adams, 175 km (110 mi) from Mount Rainier, and

200 km (125 mi) from Mount St. Helens, the three closest active volcanoes. At these distances, tephra (ash) is the only hazard. Mount St. Helens has been considerably more active throughout the Holocene than Mount Rainier or Mount Adams, which is the least active of the three.

Probabilistic volcanic hazard studies of the Cascade Range have been completed by the U.S. Geological Survey (Hoblitt et al. 1987, Scott et al. 1995). Figure 4 illustrates the annual probability of exceeding 1 cm of volcanic ash accumulation in Washington and Oregon following the eruption of a major Cascade Range volcano, and Figure 5 illustrates the annual probability of exceeding 10 cm of volcanic ash accumulation. Figure 6 presents this information as a volcanic ash hazard curve for the Hanford Site.

4.2 U.S. DEPARTMENT OF ENERGY DESIGN REQUIREMENTS

DOE has no specific orders or standards setting design criteria for ash loads. Criteria for determining design basis ash loads were developed specifically for the Hanford Site (Salmon 1996) to ensure that the performance goals of DOE Order 5480.28 are met. The design basis ashfall loads and recommended risk reduction factors for the Hanford Site given in Table 3 are based on the hazard curve shown in Figure 6. For Performance Categories 1, 2, and 3, ashfall need not be considered because it is not a controlling load when using the load combinations for the design and analysis found in DOE-STD-1020-94. Ashfall is considered an extreme environmental load and is not combined with other extreme environmental loads.

Table 3. Design Basis Loads for Ashfall Criteria.

Performance category	Target performance goal (P_g)	Hazard curve slope parameter (A_g)	Risk reduction factor	Ash hazard probability (P_m)	Design ashfall load (kg/m^2)
1	1×10^{-3}	5.0	2.1	2.1×10^{-3}	14.6 kg/m^2
2	5×10^{-4}	5.0	2.1	1.05×10^{-3}	24.4 kg/m^2
3	1×10^{-4}	3.1	3.0	3.0×10^{-4}	61 kg/m^2
4	1×10^{-5}	2.0	4.3	4.3×10^{-5}	146.5 kg/m^2

Note: Information in this table is from Salmon, M., 1996, Volcanic Ashfall Loads for the Hanford Site, WHC-SD-GN-ER-30038, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Operations that require air filtration or heating, ventilation, or air conditioning throughout an ashfall event must consider the impact of suspended ash on the operation. Unlike most other NPHs, some level of warning precedes volcanic hazards, especially distal ashfall. First, there is almost always increased seismic activity at the volcano, occurring from days to years before large eruptions. Further, heat gradients often increase, steam and smaller eruptions may be emitted from the volcano, and measurable

Figure 4. Annual Probability of One Centimeter or More of Volcanic Ash Accumulation in Washington and Oregon from Major Cascade Range Volcanoes.

Figure 5. Annual Probability of 10 Centimeters or More of Volcanic Ash Accumulation in Washington and Oregon from Major Cascade Range Volcanoes.

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CVDS

Figure 6. Cascade Range Volcanic Ash Hazard.

deformation may occur on the volcano's surface. All these warnings provide a general alert and increase emergency preparedness in the immediate area of the volcano as well as downwind in an area like the Hanford Site. Second, ash from the closest active volcanoes would take approximately 2 hours to reach the Hanford Site (Scheidegger et al. 1982). This shorter warning time is for the much higher probability that the ash will affect the Site and may lend itself to administrative controls for ashfall mitigation. Administrative procedures implemented after an eruption should be used when mitigation can be achieved through evacuation; reconfiguration of the structure, system, or component; shutdown of operations; or other activities appropriate for the specific facility or operation. Should it be determined that a safe configuration cannot be achieved during the 2-hour warning time preceding the ashfall, the appropriate suspended ash load will be determined.

4.3 U.S. NUCLEAR REGULATORY COMMISSION DESIGN REQUIREMENTS

There is no NRC design requirement or regulatory guide for volcanic hazards, namely ashfall. The Supply System's Hanford Site design basis for ashfall for safety-related structures, systems, and components is 117 kg/m^2 (24 lb/ft^2), which represents 7.4 cm (3 in.) of compacted ash (NRC 1982) with a dry compacted density of $1,538 \text{ kg/m}^3$ (96 lb/ft^3). The Supply System ash load, which is larger than the DOE requirement, is applied to the CVDS.

As with the DOE requirements, the appropriate suspended ash load will be determined if required.

5.0 FLOOD CRITERIA

5.1 BACKGROUND

The CVDS facility site is at an elevation of about 140 m (460 ft) above mean sea level and approximately 0.8 km (0.5 m) from the Columbia River (Figure 1). The level of the probable maximum flood at the 100 K Area, not considering potential dam failure, is approximately 131 m (430 ft) above mean sea level or about 9 m (30 ft) below the proposed CVDS site (ERDA 1976). The flood that results from a 25% breach of Grand Coulee Dam is estimated to reach 140 m (460 ft) above mean sea level, which is approximately the level of the ground surface of the CVDS site.

5.2 U.S. DEPARTMENT OF ENERGY DESIGN REQUIREMENTS

5.2.1 Local Runoff

DOE guidance in DOE-STD-1020-94 states that the performance goals for structures, systems, and components must be satisfied when subjected to the design basis flood for local precipitation. This can be done through design features that provide sufficient runoff capacity and through facility strengthening. The performance goal is 1×10^{-4} for a Performance Category 3

structure such as the CVDS. The probable maximum precipitation (PMP) is conservatively assumed to have an annual probability of exceedance of less than 1×10^{-6} (ASCE 1988). The NRC requirement is the PMP, which is a lower probability storm and higher precipitation than the DOE requirement.

5.2.2 River Flooding

The Performance Category 3 flood level at the 100 K Area is based upon a probabilistic flood hazard assessment of the Columbia River performed as part of a safety evaluation of the Hanford Site's N Reactor (McCann and Boissonnade 1988). The most extreme floods on the Columbia River are likely to occur as a result of dam failure. Specifically, failure of Grand Coulee and Mica dams poses the greatest threat. Dam failure is most likely to be initiated by seismic events. Conservative estimates of the seismic capacity of upstream dams are based primarily on engineering judgment and the historic frequency of dam failures. See UCRL-21069, *Probabilistic Flood Hazard Assessment for the N-Reacto, Hanford, Washington* (McCann and Boissonnade 1988), for a detailed discussion of the hazard assessment. The Performance Category 3 (1×10^{-6} probability of exceedance) flood level at the 100 K Area is estimated to be about 137 m (450 ft) above mean sea level (Tallman 1996).

5.3 U.S. NUCLEAR REGULATORY COMMISSION DESIGN REQUIREMENTS

NRC guidance in 10 CFR 72 says that "the facility must be sited so as to avoid to the extent possible the long-term and short-term adverse impacts associated with the occupancy and modification of floodplains." No guidance is given for the probabilities of flooding or precipitation to be addressed. The 24-hour PMP estimates are recommended for use in constructing runoff models for nuclear power reactors to estimate the discharge to the site's storm drainage system (NRC 1981, ANSI/ANS 1992).

5.3.1 Local Runoff

The PMP is used to assess local runoff and flood protection from intense precipitation for NRC power reactor design. A recent cooperative study by the National Oceanic and Atmospheric Administration, the Bureau of Reclamation, and the Corps of Engineers has updated the PMP estimates for the Pacific Northwest (Hansen et al. 1994). This document supersedes other earlier work done by these organizations and is the source used for the PMPs shown in Table 4. The PMP values are estimates of the maximum precipitation physically possible for both general storms (large air mass interactions) and local storms (unstable air, thunderstorms). At the Hanford Site the 6-hour local storm produces more precipitation than the 24-hour general storm. No annual probability of exceedance is given in Hydrometeorological Report No. 57, *Probable Maximum Precipitation — Pacific Northwest States* (Hansen et al. 1994), for the PMP for either general or local storms.

Table 4. Extreme Precipitation Estimates for the Hanford Site.

Time	PMP 24-hour general storm (in./10 mi ²) ^a	PMP local storm (in./1 mi ²) ^a	PMP local storm (in./10 mi ²) ^a	25-year average return period ^b	100-year average return period ^b	1,000-year average return period ^b
15 minutes	--	4.0	3.2	--	--	--
20 minutes	--	--	--	0.47	0.60	0.80
30 minutes	--	6.0	4.8	--	--	--
45 minutes	--	7.2	5.8	--	--	--
1 hour	1.6	8.0	6.4	0.62	0.81	1.11
6 hours	4.7	9.2	7.4	1.21	1.59	2.20
24 hours	8.0	--	--	1.56	1.99	2.68
48 hours	9.6	--	--	--	--	--
72 hours	10.4	--	--	--	--	--

Note: To convert precipitation depths to centimeters, multiply by 2.54.

^aHansen, E. M., D. D. Fenn, P. Corrigan, J. L. Vogel, L. C. Schreiner, and R. W. Stodt, 1994, Probable Maximum Precipitation - Pacific Northwest States, Hydrometeorological Report No. 57, National Weather Service, Silver Spring, Maryland.

^bStone, W. A., J. M. Thorp, O. P. Gifford, and D. J. Hoitink, 1983, Climatological Summary for the Hanford Site, PNL-4622, Pacific Northwest Laboratory, Richland, Washington.

PMP = probable maximum precipitation.

At the Hanford Site, using the PMP for the local storm is more conservative than using the PMP for the general storm, which occurs over a larger area. The PMP for a local 1-mi², 6-hour storm (23.4 cm [9.2 in.]) will be used for the CVDS design (Table 4). The slightly lower 10-mi² rate (18.8 cm [7.4 in.] in 6 hours) will be used for calculating the surrounding watershed runoff.

5.3.2 River Flooding

The Columbia River flood design criterion for WNP-2 is the 25% breach of the Grand Coulee Dam (ERDA 1976). The elevation of this flood at the 100 K Area is about 140 m (460 ft) above mean sea level. This level is the design criterion to be applied to the CVDS facility as it exceeds the DOE requirement of 137 m by about 3 m.

6.0 LIGHTNING

Neither DOE nor NRC have developed specific requirements for dealing with lightning. NFPA 780, *Lightning Protection* (NFPA 1992), is recommended as guidance by DOE and NRC and will be applied for lightning protection for the CVDS facility.

7.0 SNOW LOAD

Both DOE and NRC recommend following ASCE-7 (ASCE 1993) for ground snow loads and design guidance. The Supply System's ground snow load of 98 kg/m² (20 lb/ft²) is the design criterion to be applied to the CVDS facility.

8.0 REFERENCES

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APPENDIX A

**WNP-2, OPERATING LICENSE NPF-21, REQUEST FOR APPROVAL
TO REVISE TORNADO DESIGN CRITERIA**

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

P.O. Box 968 • 3000 George Washington Way • Richland, Washington 99352-0968 • (509) 372-5000

October 10, 1995
GO2-95-212

Docket No. 50-397

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: **WNP-2, OPERATING LICENSE NPF-21**
 REQUEST FOR APPROVAL TO REVISE TORNADO DESIGN CRITERIA

- References: 1) Letter G02-91-116, dated June 7, 1991, GC Sorensen (SS) to NRC, same subject
- 2) Letter G02-94-001, dated January 6, 1994, JV Parrish (SS) to NRC, same subject
- 3) Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design, NUREG-1503, July 1994
- 4) NUREG-0892, Safety Evaluation Report Related to the Operation of WPPSS Nuclear Project No.2, March 1982
- 5) NUREG-0800, Standard Review Plan, June 1987
- 6) Regulatory Guide 1.76, April-1974, Design Basis Tornado for Nuclear Power Plants.

By References 1 and 2, in accordance with the guidance of Reference 6, Section C.2, the Supply System requested approval to revise the WNP-2 tornado design criteria. Reference 1 requested that the total design basis tornado wind speed for WNP-2 be revised to 180 mph. Based on discussions with the staff, the Supply System revised its request via Reference 2 to set the tornado design basis wind speed to 192 mph. Although the Supply System feels that each of these submittals is technically justified, the Supply System is hereby further revising its request to establish the total design basis wind speed to 200 mph. The current request is based on further discussions with the staff and is consistent with the design basis tornado characteristics accepted by the NRC in Reference 3 for the tornado intensity region containing WNP-2. The complete definition of the proposed design basis tornado characteristics including the proposed design basis missiles are provided in the attachment.

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REQUEST FOR APPROVAL TO REVISE TORNADO DESIGN CRITERIA

Should you have any questions or desire additional information regarding this matter, please call me or D. A. Swank at (509) 377-4563.

Sincerely,

J. V. Parrish (Mail Drop 1023)
Vice President, Nuclear Operations

WLL/REB/ml
Attachment

cc: LJ Callan - NRC RIV
KE Perkins, Jr. - NRC RIV, Walnut Creek Field Office
NS Reynolds - Winston & Strawn
JW Clifford - NRC
DL Williams - BPA/399
NRC Sr. Resident Inspector - 927N

Attachment

WNP-2 current tornado design criteria, as stated in WNP-2 FSAR Sections 2.3.1.2.1.3 and 3.3.2.1, are for wind speeds of 300 mph rotational and 60 mph translational, with a pressure drop of 3 psi to occur in 3 seconds. These criteria were found acceptable by the staff as documented in Reference 4, Section 3.3.2. The Supply System proposes to change the design criteria to 160 and 40 mph rotational and translational velocities with a pressure drop of 0.90 psi occurring at 0.30 psi/sec.

Relative to the requirements of Reference 6, the current design requirements are conservative in that WNP-2 is a Region III site for which the criteria are 190 mph rotational and 50 mph translational with a 1.5 psi pressure drop at 0.6 psi/sec. WNP-2 FSAR Section 3.3.2.4 and Appendix C.3 discuss the WNP-2 design relative to Reference 6. It is apparent that the currently proposed criteria are less than those proposed by the Regulatory Guide for a Region III plant.

WNP-2 FSAR Section 3.5.1.4 establishes the following design basis tornado generated missiles:

Missile	Weight (lbs)	Dimensions	Horizontal Impact Velocity (ft/sec)
Utility Pole	1600	14" dia x 35'	241
Steel Rod	8	1" dia x 3'	259

The NRC found these missiles acceptable in Section 3.5.1.4 of Reference 4.

Based upon the guidance of Reference 6, NRC approval of the use of revised tornado design criteria is requested. The criteria are:

Wind Speeds:

200 mph maximum
160 mph rotational
40 mph translational

Pressure Drop:

0.90 psi
at 0.30 psi/sec

Missiles:

Missile	Weight (lbs)	Dimensions	Horizontal Impact Velocity (ft/sec)
Wood Plank	115	3.6" x 0.94' x 12' long	161.7
6" Sch 40 Pipe	287	6.6" dia x 15' long	27.0
1" Steel Rod	8.8	1" dia x 3' long	24.9
Utility Pole	1124	13.5" dia x 35' long	30.7
12" Sch 40 Pipe	750	12.75" dia x 15' long	21.8
Automobile	3990	16.4' x 6.6' x 4.3'	105.2

Consistent with Reference 5, Section 3.5.1.4, these missiles are considered to strike surfaces in any direction. Vertical velocities are taken to be 70 percent of the horizontal velocities except for the 1" steel rod which is assumed to have the same velocity in any direction. The utility pole and the automobile are considered to strike surfaces at any elevation up to a maximum elevation of 30 feet above the highest finished grade within 0.5 miles of the plant. The other missiles are considered to strike at any elevation.

Based on Reference 5, Section 3.3.2, total tornado loads resulting from wind loads, differential pressure loads, and tornado generated missiles will be established from the following equations:

$$\begin{aligned}
 W' &= W_w \\
 W' &= W_p \\
 W' &= W_m \\
 W' &= W_w + 0.5 W_p \\
 W' &= W_w + W_m \\
 W' &= W_w + 0.5 W_p + W_m
 \end{aligned}$$

where:

$$\begin{aligned}
 W' &= \text{Total tornado load} \\
 W_w &= \text{Tornado wind load} \\
 W_p &= \text{Tornado differential pressure load} \\
 W_m &= \text{Tornado generated missile load}
 \end{aligned}$$

The above wind speed and pressure drop parameters are consistent with those values approved by the NRC for the Advanced Boiling Water Reactor Design for Tornado Intensity in Region III as defined in Section 2.0 of Reference 3. Based on the extensive studies which define site specific tornado hazards for the Hanford area, these wind speed and pressure drop parameters are conservative for the WNP-2 site. These studies are discussed in detail in the report attached to Reference 2.

In addition, the Supply System is proposing that the missiles to be considered consist of the full spectrum of missiles contained in Reference 5, Section 3.5.1.4. For those missiles, the proposed velocities are based on the above wind speed and pressure drop parameters. These missile velocities were developed by the Supply System using a methodology that we feel is consistent with that used to develop the SRP missile velocities. The Supply System will formalize the calculations associated with the development of these missile velocities after NRC has concurred with the proposed revised tornado design criteria, but prior to use in design work.

By implementing the proposed revisions, the tornado design criteria will conservatively reflect the tornado hazards at WNP-2 while maintaining the objective of providing an annual probability of exceedance of design loads of less than or equal to 1×10^{-7} . These revisions will result in more realistic wind velocities, differential pressure loads, missile velocities, and load combinations. The proposed revisions will benefit the design of exterior structures and components that must consider postulated tornado effects. Significant benefit is expected during the implementation of future plant modifications where the revised tornado design criteria will facilitate construction. An example of this application is the Supply System's current effort to procure and install a dry cask spent fuel storage facility.

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APPENDIX B

**REVISION OF TORNADO DESIGN CRITERIA FOR THE WASHINGTON
PUBLIC POWER SUPPLY SYSTEM (WPPSS)
NUCLEAR PROJECT NO. 2 (WNP-2)**

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

GI 2-90-032

January 24, 1996

RECEIVED

24 1996

Mr. J. V. Parrish (Mail Drop 1023)
Vice President Nuclear Operations
3000 George Washington Way
Washington Public Power Supply System
P.O. Box 968
Richland, Washington 99352-0968

SUBJECT: REVISION OF TORNADO DESIGN CRITERIA FOR THE WASHINGTON PUBLIC
POWER SUPPLY SYSTEM (WPPSS) NUCLEAR PROJECT NO. 2 (WNP-2)
(TAC NO. M88626)

Dear Mr. Parrish:

By letter dated January 6, 1994, as modified by letter dated October 10, 1995, you requested staff review and approval of a proposed revision to the tornado design criteria for WNP-2. Our review is documented in the enclosed safety evaluation. We have determined that your proposed changes to the design tornado wind speeds and missile spectrum are acceptable.

This completes our work on TAC No. M88626. Please contact me at 301-415-1352 if you have any questions.

Sincerely,

James W. Clifford
James W. Clifford, Senior Project Manager
Project Directorate IV-2
Division of Reactor Projects - III/IV
Office of Nuclear Reactor Regulation

Docket No. 50-397

Enclosure: Safety Evaluation

cc w/enclosure:
See next page

Mr. J. V. Parrish

- 2 -

cc w/encl:

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UNITED STATES
 NUCLEAR REGULATORY COMMISSION
 WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REVISED TORNADO DESIGN CRITERIA

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

NUCLEAR PROJECT NO. 2

DOCKET NO. 50-397

1.0 INTRODUCTION

By letter dated January 6, 1994, the Washington Public Power Supply System (the Supply System or the licensee) requested the staff's approval to revise the tornado design criteria for the WPPSS Nuclear Project No. 2, (WNP-2). By letter dated July 13, 1995, the staff requested additional justification for the licensee's proposed maximum composite wind speed of 192 mph. By letter dated October 10, 1995, the Supply System modified their proposed maximum composite wind speed to 200 mph and provided supporting justification. The current licensing basis tornado design criteria for WNP-2 are wind speeds of 300 miles per hour (mph) rotational and 60 mph translational. The proposed change, as requested in the October 10, 1995 submittal, would revise the criteria to establish the total design basis tornado wind speed at 200 mph (160 mph rotational and 40 mph translational). The request is based on the design basis tornado characteristics (for the tornado intensity region in which WNP-2 is located) accepted by the staff in NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," July 1994.

2.0 EVALUATION

The current licensing basis tornado design criteria for WNP-2 are based on a tornado Region I plant site as defined in Regulatory Guide (RG) 1.76, "Design Basis Tornado for Nuclear Power Plants." These are excessive criteria for WNP-2 because it is located in a tornado Region III as defined in RG 1.76. The licensee's proposed tornado wind speed is also less than the wind speed identified in RG 1.76 for a design basis Region III tornado. This further reduction in tornado design criteria is consistent with the design basis characteristics accepted by the staff in NUREG-1503. Table 2-1 of NUREG-1503 establishes revised design basis tornado characteristics that are acceptable to the staff. The licensee's proposed revision is consistent with that table.

In NUREG-1503, the staff refers to SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," dated April 2, 1993, as a basis for revised tornado wind speeds. As described in SECY-93-087, the staff reevaluated the regulatory positions in RG 1.76 using the considerable quantity of tornado data which has become available since RG 1.76 was developed. This reevaluation is discussed

- 2 -

in NUREG/CR-4661, "Tornado Climatology of the Contiguous United States," dated May 1986. Based on the updated tornado data and the analysis provided in NUREG/CR-4661, the staff concluded (in SECY-93-087) that it is acceptable to reduce the tornado design basis wind speeds to 322 kilometers per hour (km/hr) (200 mph) for states west of the Rocky Mountains and to 482 km/hr (300 mph) for states east of the Rocky Mountains. The staff, therefore, concludes that the licensee's proposed reduction in design basis tornado wind speed to 200 mph is acceptable for WNP-2 which is located west of the Rocky Mountains. The licensee's proposed pressure drop and rate of pressure drop associated with the 200 mph tornado are also acceptable because they are consistent with the design basis tornado characteristics found acceptable to the staff in Table 2-1 of NUREG-1503.

The licensee also proposed to revise the design basis tornado missile spectrum associated with the revised design basis tornado for WNP-2. The licensee calculated the impact velocities for the proposed tornado missile spectrum based on the reduced wind speed of 200 mph. The licensee's proposal used Missile Spectrum II identified in Section 3.5.1.4 of the Standard Review Plan (SRP). Because the missile spectrum is consistent with Section 3.5.1.4 of the SRP, the staff concludes that it is acceptable.

It should also be recognized that the tornado design basis requirements have been used in establishing structural requirements (minimum concrete wall thicknesses) for the protection of safety-related structures, systems, and components against effects not covered explicitly in review guidance such as regulatory guides and the Standard Review Plan. Specifically, some aviation (general aviation light aircraft) crashes, nearby explosions, and explosion debris or missiles have been reviewed and evaluated routinely by the staff by taking into account the existence of the tornado protection requirements. Therefore, for any new structures that are built using the revised tornado design criteria, the licensee should perform an analysis under 10 CFR 50.59 to verify that the structures are adequate, based on minimum wall thickness, have walls thick enough to protect against other postulated site-specific hazards or loads that may have been previously subsumed within the tornado design basis.

3.0 CONCLUSION

Based on the above evaluation, the staff concludes that the licensee's proposed revised criteria for the design basis tornado are in accordance with the guidelines of RG 1.76 regarding the missile spectrum and with the staff's revised design basis tornado characteristics set forth in NUREG-1503. The staff, therefore, concludes that the proposed changes are acceptable.

Principal Contributor: W. LeFave

Date: January 24, 1996