

BROOKHAVEN NATIONAL LABORATORY
MEMORANDUM

DATE: May 7, 1985
TO: W. T. Pratt *WTP*
FROM: K. R. Perkins and V. L. Sailor *NLS*
SUBJECT: Descriptions of Spent Fuel Pools

This memorandum presents data compiled in partial fulfillment of Task 1.b, Work Requirements, Schedule 189, Section 3.a of Project Title: "Study of Beyond Design Basis Accidents in Spent Fuel Pools (Generic Issue 82)" which specifies that "BNL will compile descriptions of spent fuel pools at all operating plants and plants under construction." Note that the data cover only the operating plants since the plants under construction do not have spent fuel inventories. The emphasis on seismic data is consistent with the results of our likelihood evaluation (Task 2.a of the Project Description).

The compilation of data is intended to aid in establishing a priority list for those plants which may warrant further investigation. The data will also be used to identify the most vulnerable designs for our failure frequency and risk estimates (Tasks 6 and 7 of the Project Description).

The relevant data are listed in Table 1 (BWRs) and Table 2 (PWRs). The data listed are as follows:

Column 1: Plant Name

Column 2: Licensed thermal power (MWt).¹

Column 3: Number of fuel assemblies in the reactor core.¹

Column 4: Number of spent fuel assemblies stored in spent fuel basin as of December 31, 1984.¹

Column 5: Fractions of core stored in spent fuel basin (Column 4/Column 3).

Column 6: Radioactive inventory in spent fuel basin relative to "reference case" (expressed in per cent of "reference case"). The "reference case" is defined as the radioactive inventory in spent fuel accumulated from ten annual refuelings of a 1000 MWe plant with fuel burnup of 33,000 MWd/MTU, and the last discharge being six months ago. Account is taken for the radioactive decay of individual radionuclides. The "reference case" is more fully described in Reference 2.

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Column 7: Location of the spent fuel basin, i.e., whether in the reactor building (RB), an auxiliary building (AB), or fuel handling building (FB) and whether the pool is at or near grade (grd) or at an elevated location (ele).³

Column 8: Seismic Design Basis.³ This lists the horizontal component of the ground acceleration for the design basis earthquake (DBE) or the safe shutdown earthquake (SSE).

The DBE pertains to plants which were under construction prior to the effective date of 10CFR100, Appendix A in 1973. In general, the design basis assumed simultaneous vertical accelerations of 2/3 horizontal and used a generic frequency spectrum based on observed seismic events, e.g., the "Housner Spectrum." In most cases, the DBE maximum horizontal acceleration applied to structures with foundations on bed rock. Higher accelerations, e.g., DBE x 1.5, were usually applied to structures founded on soil.

SSE entries imply that the designs were in compliance with 10CFR100, Appendix A.

Plants in seismically active regions (San Onofre 2 & 3), Diablo Canyon, etc.) were subjected to more complex analyses.

More detailed seismic design data for 71 operating reactors are compiled in Reference 4.

References

1. U. S. Nuclear Regulatory Commission, Licensed Operating Reactors, NUREG-0020, Vol. 9, No. 1, January 1985.
2. BNL Memorandum to W. T. Pratt from V. L. Sailor and K. R. Perkins, "Study of Beyond Design Basis Accidents in Spent Fuel Pools (Generic Issue 82)," Section 5.2, April 3, 1985.
3. Safety Analysis Reports (SARs) for the individual plants.
4. M. Subudhi, M. Reich, B. Koplik, and J. Lane, Seismic Review Table, prepared for the U. S. Nuclear Regulatory Commission by Brookhaven National Laboratory, NUREG/CR-1429, May 1980.

KRP/VLS:tr

TABLE 1 BWR's: DATA ON SPENT FUEL STORAGE BASINS. Included are spent fuel storage inventories as of December 1984, fractions of core in storage, comparisons with the "reference case" of radionuclide inventory, locations of spent fuel basins, and seismic design bases of pools.

Plant	Thermal Power (MWt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Big Rock Point	240	84	172	2.05	4.9	AB, grd	DBE=0.05g
Browns Ferry-1	3293	764	1068	1.40	46.1	RB, ele	DBE=0.20g
Browns Ferry-2	3293	764	889	1.16	38.2	RB, ele	DBE=0.20g
Browns Ferry-3	3293	764	1768	2.31	76.1	RB, ele	DBE=0.20g
Brunswick-1	2436	560	1056 ^f	1.89	46.0	RB, ele	DBE=0.16g
Brunswick-2	2436	560	924 ^g	1.65	40.2	RB, ele	DBE=0.16g
Cooper	2381	548	985	1.80	42.9	RB, ele	DBE=0.2g
Dresden-1	700	464	221	0.48	3.36		DBE=0.20g
Dresden-2	2527	724	2014 ^h	2.78 ^h	70.3 ^h	RB, ele	DBE=0.2g
Dresden-3	2527	724	-	-	-	RB, ele	DBE=0.2g
Duane Arnold	1658	368	576	1.57	26.0	RB, ele	DBE=0.12g
Fitzpatrick	2436	560	816	1.46	35.6	RB, ele	DBE=0.15g
Grand Gulf-1	3833	N/A ⁱ	0	0.00	0.0	N/A	
Hatch-1	2436	560	140	0.25	6.1	RB, ele	DBE=0.15g

TABLE 1 (Cont.)

Plant	Thermal Power (Mwt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Hatch-2	2436	560	1284	2.	55.8	RB, ele	DBE=0.15g
Humboldt Bay	220	172	251	1.46	3.2	N/A	DBE=0.50g
LaCrosse	165	72	207	2.88	4.8	AB, grd	DBE=0.12g
LaSalle-1	3323	N/A	0	0.00	0.0	RB, ele	SSE=0.20g
LaSalle-2	3323	N/A	0	0.00	0.0	RB, ele	SSE=0.20g
Limerick-1	3293	N/A	0	0.00	0.0	RB, ele	SSE=0.13g
Millstone-1	2011	580	1346	2.32	46.7	RB, ele	DBE=0.17g
Monticello	1670	484	1137	2.35	39.2	RB, ele	DBE=0.12g
Nine Mile Point-1	1850	532	1244	2.34	43.3	RB, ele	DBE=0.11g
Oyster Creek	1930	560	1375	2.46	47.5	RB, ele	DBE=0.22g
Peach Bottom-2	3293	764	1361	1.78	58.6	RB, ele	DBE=0.12g
Peach Bottom-3	3293	764	1212	1.59	52.4	RB, ele	DBE=0.12g
Pilgrim-1	1998	580	1128	1.94	38.8	RB, ele	DBE=0.15g
Quad Cities-1	2511	724	1730	2.39	60.0	RB, ele	DBE=0.24g
Quad Cities-2	2511	724	412	0.57	14.3	RB, ele	DBE=0.24g

TABLE 1 (Cont.)

Plant	Thermal Power (Mwt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Susquehanna-1	3293	764	0	0.00	0.0	RB, ele	SSE=0.1g
Susquehanna-2	3293	764	0	0.00	0.0	RB, ele	SSE=0.1g
Vermont Yankee	1593	368	1174	3.19	50.8	RB, ele	DBE=0.14g
Wash. Nucl.-2	3323	N/A	0	0.00	0.0	N/A	SSE=0.32g

Footnotes for Table 1

- a) Source: U. S. Nuclear Regulatory Commission, Licensed Operating Reactors, NUREG-0020, Vol. 9, No. 1, January 1985.
- b) (Stored Assemblies)/(Assemblies in Core).
- c) "Reference Source Term" assumes a thermal power of 3000 Mwt, stored inventory from ten annual discharges, last discharge six months ago, total inventory 1750 assemblies. Source term relative to "Reference Source Term" has not been corrected for age of fuel in storage.
- d) Location: RB = reactor building, AB = auxiliary building, grd = pool at grade level, ele = pool at high elevation in building.
- e) Seismic design basis as a function of the gravitational acceleration (g): DBE = design basis earthquake, or equivalent as used for older vintage plants; SSE = safe shutdown earthquake as defined in 10 CFR 100, App. A. Entry shown is the horizontal component.
- f) Brunswick-1 has in storage 160 PWR + 656 BWR assemblies, equivalent to 1056 BWR assemblies.
- g) Brunswick-2 has in storage 144 PWR + 564 BWR assemblies, equivalent to 924 BWR assemblies.
- h) Dresden Units 2 and 3 have two pools in one structure. The data cited are total of the two.
- i) N/A = data not available.

TABLE 2 PWR's: DATA ON SPENT FUEL STORAGE BASINS. Included are spent fuel storage inventories as of December 1984, fractions of core in storage, comparisons with the "reference case" of radionuclide inventory, locations of spent fuel basins, and seismic design bases of pools.

Plant	Thermal Power (MWt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Arkansas-1	2568	177	388	2.19	56.3	AB, grd	DBE=0.2g
Arkansas-2	2815	177	168	0.95	26.7	AB, grd	DBE=0.2g
Beaver Valley-1	2660	157	104	0.66	17.6	FB, grd	SSE=0.125g
Byron-1	^f N/A	N/A	0	0.00	0.0	AB, grd	SSE=0.2g
Callaway-1	3411	N/A	N/A	N/A	N/A	AB, grd	SSE=0.2g
Calvert Cliffs-1	2700	217	^g 868	^j 4.00	^g 108.0	AB, grd	DBE=0.15g
Calvert Cliffs-2	2700	217	-	-	-	AB, grd	DPE=0.15g
Catawba-1	N/A	N/A	N/A	N/A	N/A	AB, grd	SSE=0.12g
Cook-1	3250	193	^g 553	^g 2.87	^g 93.1	AB, grd	SSE=0.20g
Cook-2	3411	193	-	-	-	AB, grd	SSE=0.20g
Crystal River-3	2544	177	171	0.97	24.6	AB, grd	SSE=0.10g
Davis Besse-1	2772	177	199	1.12	31.2	AB, grd	DBE=0.15g
Diablo Canyon-1	3338	N/A	N/A	N/A	N/A	AB, grd	^j DOE=0.4g
Farley-1	2652	157	114	0.73	19.3	AB, grd	SSE=0.10g

TABLE 2 (Cont.)

Plant	Thermal Power (MWt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Farley-2	2652	157	62	0.39	10.5	AB, grd	SSE=0.10g
Fort Calhoun	1500	133	305	2.29	34.4	AB, grd	DBE=0.17g
Ginna	1520	121	340	2.81	42.7	AB, grd	DBE=0.20g
Haddam Neck	1825	157	545	3.47	63.4	AB, grd	DBE=0.17g
Indian Point-1	h	h 0	160	h	h	AB, grd	DBE=0.10g
Indian Point-2	2758	193	332	1.72	47.4	AB, grd	DBE=0.15g
Indian Point-3	3025	193	140	0.73	21.9	AB, grd	DBE=0.15g
Kewaunee	1650	121	268	2.21	36.5	AB, grd	DBE=0.12g
Maine Yankee	2630	217	577	2.66	69.9	AB, grd	DBE=0.10g
McGuire-1	3411	193	91	0.47	16.1	AB, grd	SSE=0.15g
McGuire-2	3411	N/A	N/A	N/A	N/A	AB, grd	SSE=0.15g
Millstone-2	2700	217	376	1.73	46.8	AB, grd	DCG=0.17g
North Anna-1	2775	157	220 ^g	1.40 ^g	38.9 ^g	AB, grd	SSE=0.12g
North Anna-2	2775	157	-	-	-	AB, grd	SSE=0.12g
Oconee-1	2568	177	1037 ^g	5.85 ^g	150.5 ^g	AB, grd	DBE=0.10g

TABLE 2 (Cont.)

Plant	Thermal Power (MWt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Oconee-2	2568	177	-	-	-	AB, grd	DBE=0.1g
Oconee-3	2568	177	218	..23	31.6	AB, grd	DBE=0.1g
Palisades	2530	204	480	2.35	59.5	AB, grd	DBE=0.20g
Palo Verde-1	N/A	N/A	N/A	N/A	N/A	AB, grd	SSE=0.20g
Point Beach-1	1518	121	524 ^g	4.33 ^g	65.7 ^g	AB, grd	DBE=0.18g
Point Beach-2	1518	121	-	-	-	AB, grd	DBE=0.18g
Prairie Island-1	1650	121	601 ^g	4.97 ^g	82.0 ^g	AB, grd	SSE=0.12g
Prairie Island-2	1650	121	-	-	-	AB, grd	SSE=0.12g
Rancho Seco-1	2772	177	260	1.47	40.7	AB, grd	SSE=0.25g
Robinson-2	2300	157	152	0.97	22.3	AB, grd	DBE=0.20g
Salem-1	3338	193	296	1.53	51.2	AB, grd	DBE=0.20g
Salem-2	3411	193	265	1.37	46.8	AB, grd	DBE=0.20g
San Onofre-1	1347	157	94	0.60	8.1	AB, grd	DBE=0.50g
San Onofre-2	3410	217	217	1.00	34.1	AB, grd	SSE=0.67g
San Onofre-3	3390	217	0	0.00	0.0	AB, grd	SSE=0.67g

TABLE 2 (Cont.)

Plant	Thermal Power (MWt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Sequoyah-1	3411	193	65	0.34	11.5	AB, grd	SSE=0.18g
Sequoyah-2	3411	193	130	0.67	23.0	AB, grd	SSE=0.18g
St. Lucie-1	2700	217	352	1.62	43.8	AB, grd	DBE=0.10g
St. Lucie-2	2560	N/A	N/A	N/A	N/A	AB, grd	SSE=0.10g
Summer-1	2775	157	52	0.33	9.2	AB, grd	SSE=0.15g
Surry-1	2441	157	608 ^g	3.87 ^g	94.5 ^g	AB, grd	SSE=0.15g
Surry-2	2441	157	-	-	-	AB, grd	SSE=0.15g
Three Mile Island-1	2535	177	208	1.18	29.8	AB, grd	DBE=0.12g
Three Mile Island-2	1	177	0	0.00	0.0	AB, grd	SSE=0.12g
Trojan	3411	193	312	1.62	55.1	AB, grd	DBE=0.25g
Turkey Point-3	2200	157	445	2.83	62.4	AB, grd	DBE=0.15g
Turkey Point-4	2200	157	430	2.74	60.3	AB, grd	DBE=0.15g
Waterford-3	N/A	N/A	N/A	N/A	N/A	AB, grd	SSE=0.10g
Yankee Rowe	600	76	250	3.29	19.7	AB, grd	None

TABLE 2 (Cont.)

Plant	Thermal Power (Mwt)	Number of Fuel Assemblies in Core ^a	Spent Fuel Stored Inventory ^a (No. of Assemblies)	Stored Inventory Fractions of Core ^b	Radioactivity Relative to Reference Case ^c (per cent)	Storage Pool Location ^d	Seismic Design Basis ^e
Zion-1	3250	193	863 ^g	4.47 ^g	145.3 ^g	AB, grd	SSE=0.17g
Zion-2	3250	193	-	-	-	AB, grd	SSE=0.17g

Footnotes for Table 2

- a) Source: U. S. Nuclear Regulatory Commission, Licensed Operating Reactors, NUREG-0020, Vol. 9, No. 1, January 1985.
- b) (Stored Assemblies)/(Assemblies in Core).
- c) "Reference Source Term" assumes a thermal power of 3000 Mwt, stored inventory from ten annual discharges, last discharge six months ago, total inventory 700 assemblies. Source term relative to "Reference Source Term" has not been corrected for age of fuel in storage.
- d) Location: RB = reactor building, AB = auxiliary building, FB = fuel building, g = pool at grade level, e = pool at high elevation in building.
- e) Seismic design basis as a fraction of the gravitational acceleration (g): DBE = design basis earthquake, or equivalent as used for older vintage plants; SSE = safe shutdown earthquake as defined in 10 CFR 100, App. A. Entry shown is the horizontal component.
- f) N/A = data not available.
- g) Spent fuel basin shared by two units. Entries shown are totals.
- h) Indian Point-1 is permanently shutdown.
- i) TMI-2 is indefinitely shutdown.
- j) Diablo Canyon originally used the "Double Design Earthquake," DDE acceleration = 2 DBE. Later, more elaborate analysis was done to postulate an earthquake of 0.5g associated with the Hosgri Fault.