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SORENSEN,G.C. Washington Public Power Supply System
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SUBJECT: Suppls listed responses to NRC Bulletin 90-002, "Loss of Thermal Margin Caused by Channel Box Bow," effect on Cycle 9 operation.Requests NRC approval for plan to reuse channel boxes during Cycle 9.

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

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February 2, 1993
G02-93-024

Docket No. 50-397

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

Subject: **WNP-2, OPERATING LICENSE NPF-21 RESPONSE TO NRC BULLETIN NO. 90-02: "LOSS OF THERMAL MARGIN CAUSED BY CHANNEL BOX BOW", EFFECT ON CYCLE 9 OPERATION (TAC No. M82920)**

References:

1. NRC Bulletin No. 90-02, March 20, 1990, "Loss of Thermal Margin Caused by Channel Box Bow"
2. Letter, G02-90-075, April 13, 1990, GC Sorensen (SS) to USNRC, "Modification of WNP-2 Cycle 6 Reload Submittal and Response to NRC Bulletin No. 90-02: Loss of Thermal margin Caused by Channel Box Bow"
3. ANF-524(P)(A), Rev. 2, Supplements 1 and 2, November 1990, "Advanced Nuclear Fuels Corporation Critical Power Methodology for Boiling Water Reactors"
4. Letter, G02-90-162, September 28, 1990, GC Sorensen (SS) to USNRC, "Final Response to NRC Bulletin No. 90-02: Loss of Thermal Margin Caused by Channel Box Bow"
5. Letter, G02-91-037, February 25, 1991, GC Sorensen (SS) to USNRC, "Request for Additional Information Regarding NRC Bulletin 90-02, Loss of Thermal Margin Caused by Channel Box Bow"
6. Letter, April 22, 1991, PL Eng (NRC) to GC Sorensen (SS), "Evaluation of Response to NRC Bulletin No. 90-02: Loss of Thermal Margin Caused by Channel Box Bow (TAC No. 76354)"
7. Letter, G02-92-048, February 25, 1992, GC Sorensen to USNRC, "Response to NRC Bulletin No. 90-02: Loss of Thermal Margin Caused by Channel Box Bow, Effect on Cycle 8 Operation"
8. Letter, June 15, 1992, WM Dean (NRC) to GC Sorensen, "Evaluation of Response to NRC Bulletin No. 90-02: Loss of Thermal Margin Caused by Channel Box Bow (TAC No. M82920)"

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Reference 1 requested that licensees reusing channel boxes verify that current Minimum Critical Power Ratio (MCPR) Technical Specification operating and safety limits are met. All affected licensees were requested to advise the NRC of the number and location of such channel boxes and to describe the methods and associated data base used to account for the effects of channel box bow during reuse of channel boxes to ensure conformance with the CPR limits.

The Supply System responded to this bulletin in References 2, 4, 5 and 7. Reference 6 provided WNP-2 the NRC evaluation of the issues for Cycle 7, and Reference 8 for Cycle 8. Reference 6 required that the reuse of channel boxes in future cycles be evaluated on a cycle specific basis. This letter responds to those requirements for WNP-2 Cycle 9. The effect of potential channel box bow on CPR limits was evaluated in the Cycle 9 design.

WNP-2, a C-lattice BWR, is less susceptible than a D-lattice BWR to the phenomena of and effects from channel box bow. The Supply System, aware of the potential problems associated with channel box bow, has had a channel management program in place since initial operation of WNP-2. The WNP-2 channel management program consists of data collection on channel operating history and actual measurement of channel distortion as a function of channel operation. The current goal of the channel management program is to use a channel box for a single assembly lifetime. To achieve this goal, the Supply System is currently putting new channels on new fuel. During the transition the Supply System will discharge channels predicted to achieve a target burnup of approximately 50 GWd/MTU in a cycle or perform an analysis to justify continued use. Reference 4 discusses the basis for the selection of the exposure target and analytical methodology.

In Cycle 8, 291 of the 764 channels in the WNP-2 core were reused channels. In Cycle 9 there will be 232 reused channels. Twenty-four (24) channels will be replaced at the end of Cycle 8 because their exposures at the end of Cycle 9 are expected to exceed 50 GWd/MTU. These channels will be replaced with less exposed channels from the spent fuel pool. Each of the 24 replacement channels has been measured for channel box bow and bulge and meets the predetermined acceptance criteria of Reference 4. At the end of Cycle 9, the peak reused channel exposure is predicted to be less than 49 GWd/MTU.

EXPOSURE RANGE GWd/MTU	QUANTITY
27 - 34	42
34 - 41	42
41 - 48	148

Beginning with Cycle 7, the effects of channel box bow were addressed in WNP-2 reload design using the approved Siemens Power Corporation (SPC) methodology for determining the Safety Limit Minimum Critical Power Ratio (SLMCPR) (Reference 3). The SPC data incorporated in the SPC methodology has been reviewed previously by the NRC (including WNP-2 measured data) and along with the methodology has been approved by the NRC (Reference 3). The SLMCPR established for Cycle 9 operation of WNP-2 will include the effects of channel box bow as analyzed by this methodology.

During Cycle 9, 232 reused channels will be in the WNP–2 core. The planned location coordinates for each reused channel for Cycle 9 are given in Table 1. The location of each reused channel is also indicated on the attached Figure 1 (core map) by assembly number. The appropriate channel number for each assembly number can be determined from Table 1. A total of 76 of the reused channels will be located face adjacent to new fuel assemblies. Experience has shown that limiting assemblies are almost always once burned assemblies and, potentially at the end of a long cycle, fresh assemblies can be limiting. However, the precise location of limiting assemblies during Cycle 9 will be dependent upon the actual operating experience. A reused channel could, therefore, be adjacent to a limiting assembly at some time during Cycle 9 operation. The probability of this occuring is recognized and taken into account in calculation of the SLMCPR using the SPC methodology.

Channel distortion (bow + bulge), magnitude and direction, is directly dependent upon the location history of the channels. The channels that will have the largest estimated exposure at end of cycle are channels 60890 and 73399. The channels will reside in core location 23,2 and 23,29 respectively (row and column coordinates from the upper left corner as shown in Figure 1). The Supply System analytical model predicts a maximum calculated total distortion for these channels to be less than 105 mils. Total distortions for the other reused channels in WNP-2 shown in Table 1 are predicted to be less than this value.

The anticipated effect of maximum channel bow is accounted for in the MCPR operating limit by modification of the SLMCPR, which is a part of the MCPR operating limit. The WNP-2 SLMCPR is established through statistical consideration of measurement and calculational uncertainties associated with the thermal hydraulic state of the reactor using design basis radial, axial and local power distributions and considering fuel channel bow. Reference 3 discusses vendor MCPR safety limit methodology and describes in detail how channel bow effects are incorporated into the MCPR safety limit. The effects of channel bow increase the WNP-2 Cycle 9 MCPR safety limit by about 0.02.

In accordance with the requirements of IEB 90-02 and Reference 6, the Supply System is requesting NRC approval for this plan for the reuse of channel boxes during Cycle 9. The channels are to be loaded into the core during the spring 1993 refueling outage, scheduled for 45 days beginning in April. Therefore, prompt NRC approval of this submittal would be appreciated.

Sincerely,

G. C. Sorensen, Manager
Regulatory Programs (Mail Drop PE20)

JDF:bw

Attachments:
1. Table 1; Reused Channels, Assemblies And Projected Exposure
2. Figure 1; Cycle 9 Load Pattern Showing Assemblies with Reused Channels

cc: JB Martin - NRC RV
NS Reynolds - Winston & Strawn
JD Clifford - NRC
DL Williams - BPA/399
NRC Site Inspector - 901A

STATE OF WASHINGTON)
)
COUNTY OF BENTON)

Subject: Response to IEB 90-02

I. G. C. SORENSEN, being duly sworn, subscribe to and say that I am the Manager, Regulatory Programs for the WASHINGTON PUBLIC POWER SUPPLY SYSTEM, the applicant herein; that I have the full authority to execute this oath; that I have reviewed the foregoing; and that to the best of my knowledge, information, and belief the statements made in it are true.

DATE 2 FEBRUARY, 1993

G. C. Sorensen, Manager
Regulatory Programs

On this date personally appeared before me G. C. SORENSEN, to me known to be the individual who executed the foregoing instrument, and acknowledged that he signed the same as his free act and deed for the uses and purposes herein mentioned.

GIVEN under my hand and seal this 2nd day of February 1993.

Notary Public in and for the
STATE OF WASHINGTON

Residing at Kennewick, Washington

My Commission Expires April 28, 1994

Table 1

Reused Channels, Assemblies, and Projected EOC 9 Exposures

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
1	9	AN3042	71970	46918
1	10	AN3075	73079	47612
1	11	AN3033	73130	46740
1	12	AN3067	61769	47193
1	13	AN3066	73366	44038
1	14	AN3036	63602	44649
1	15	XN2087	71965	39247
1	16	XN2095	70104	39371
1	17	AN3008	71758	44586
1	18	AN3095	5938D	37527
1	19	AN3098	5900D	38424
1	20	AN3021	71458	46740
1	21	AN3107	71808	44849
1	22	AN3025	63257	46819
2	8	AN3068	70287	45588
2	23	AN3096	70257	45296
3	6	AN3040	73367	44748
3	7	XN2091	71387	36125
3	9	UD4034	72009	41880
3	16	XN2108	73379	40563
3	24	XN2099	61638	42632
3	25	AN3126	71933	47186
4	6	AN3099	71956	47126
4	7	AN3064	72035	41718
4	10	UD4115	70190	30912
4	14	UD4032	62686	30303
4	24	AN3028	72474	41533
4	25	AN3045	71914	47621
5	5	AN3031	71389	44510
5	11	AN3074	73425	47607
5	13	UD5066	71780	43637
5	20	AN3090	73390	47681
5	26	AN3029	72439	43969
6	3	AN3038	71756	47099
6	4	AN3051	63949	47120
6	5	AN3133	71927	45963
6	6	AN3043	6450D	37847
6	8	UD5071	71938	37852
6	9	AN3092	63572	44270
6	10	UD5064	71198	45818
6	22	AN3089	62513	44359
6	25	AN3083	71809	46523
6	26	AN3134	73384	45177
6	27	AN3119	63442	47161

Table 1 (Cont.)

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
6	28	AN3130	6012D	35556
7	3	XN2086	71300	36550
7	8	UD5070	71945	45874
7	12	AN3039	71789	45729
7	19	AN3125	71755	45584
7	27	AN3124	71376	41594
7	28	XN2094	71761	35989
8	2	AN3034	71757	45307
8	8	UD5072	70238	46115
8	10	AN3070	5881D	37854
8	11	UD4025	70279	43736
8	12	UD5063	71817	44770
8	21	AN3027	71437	46213
8	29	AN3022	72027	47311
9	1	AN3032	71942	43959
9	6	AN3104	72039	47033
9	25	AN3085	73394	46329
9	30	AN3030	71443	44097
10	1	AN3076	5809D	39001
10	4	UD4024	73124	31375
10	8	AN3079	63445	46813
10	23	AN3084	71391	47052
10	27	UD4022	73386	37823
10	30	AN3097	71400	47663
11	1	AN3100	73120	46830
11	5	AN3053	5898D	39081
11	23	UD4031	72038	44572
11	26	AN3103	73154	39070
11	30	AN3049	72024	46828
12	1	AN3052	71958	46391
12	7	AN3069	73116	46028
12	15	AN3035	71986	45280
12	16	AN3007	5960D	36559
12	24	AN3081	73111	37074
12	30	AN3120	73226	46857
13	1	AN3054	63427	45912
13	8	UD5065	61550	40884
13	30	AN3082	71447	34336
14	1	AN3080	5866D	36350
14	23	UD4029	73117	30712
14	25	UD5013	70110	46305
14	30	AN3001	71790	45294
15	1	XN2084	71936	39297
15	8	UD5030	71848	45400
15	12	AN3041	73108	44889
15	15	UD5069	63492	46029

Table 1 (Cont.)

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
15	19	AN3026	72001	45348
15	23	UD5035	71983	45006
15	30	XN2067	73582	39887
16	1	XN2066	61972	33095
16	4	UD5040	62522	43137
16	6	UD4016	71904	32845
16	7	UD4021	73232	47418
16	10	UD4143	72042	32464
16	11	UD5036	73238	42577
16	12	AN3020	63956	45756
16	15	UD5028	71962	45397
16	16	UD5025	71141	46076
16	19	AN3060	71268	45592
16	20	UD5022	70252	42717
16	21	UD4140	71801	29988
16	24	UD4003	63953	47417
16	25	UD4139	73132	30540
16	30	XN2100	71959	33173
17	1	AN3002	62283	36432
17	10	UD4144	71434	30213
17	12	UD4012	71950	33116
17	19	UD4134	70167	30230
17	21	UD4142	6028D	36462
17	29	UD5026	61750	42583
17	30	AN3122	71928	42349
18	1	AN3058	73388	45791
18	9	UD5039	70011	43890
18	22	UD5031	73415	43998
18	23	UD5021	71799	43411
18	30	AN3112	71990	45473
19	1	AN3019	71852	47231
19	10	UD4005	73089	33984
19	11	UD5010	72034	44953
19	14	UD4039	71835	32198
19	15	AN3056	61741	45434
19	16	AN3078	71967	45621
19	17	UD4007	73426	31688
19	20	UD5024	61529	44728
19	21	UD4014	72018	29767
19	24	AN3023	5850D	37057
19	30	AN3063	62937	47021
20	1	AN3086	70047	44381
20	5	AN3057	5802D	39070
20	9	UD4033	71795	30131
20	11	UD4041	71923	33693
20	12	UD5004	71908	45676

Table 1 (Cont.)

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
20	15	UD5016	71356	42790
20	16	UD5037	71830	42962
20	20	UD4036	73441	34195
20	22	UD4023	73614	39187
20	24	UD5033	70158	45086
20	26	AN3111	73135	47628
20	29	UD5023	73069	42591
20	30	AN3091	73112	46828
21	1	AN3073	72036	47663
21	2	UD4042	71943	46205
21	8	AN3128	72021	47002
21	10	UD4038	73403	31013
21	12	UD4015	5912D	34227
21	14	UD4027	71393	30450
21	15	UD4040	71786	32216
21	16	UD4035	71957	47804
21	17	UD4008	71907	30224
21	19	UD4013	71770	27878
21	21	UD4083	71953	31549
21	23	AN3016	71448	46513
21	29	UD4135	71975	43694
21	30	AN3116	63947	47633
22	1	AN3123	71991	46059
22	6	AN3050	71449	35546
22	11	UD4026	71778	30170
22	13	UD5014	71759	44377
22	20	UD4037	61931	31023
22	25	AN3093	73420	47024
22	30	AN3048	70272	43959
23	2	AN3011	60890	48146
23	8	UD5011	71930	45838
23	10	AN3131	72041	46552
23	14	UD4116	71392	31006
23	15	UD5018	61538	45268
23	17	UD4004	73444	38303
23	21	AN3121	71444	46808
23	25	UD5029	61773	44513
23	29	AN3061	73399	47943
24	3	XN2056	72023	42227
24	4	AN3037	72037	41502
24	7	UD4138	71334	30007
24	8	UD5017	63943	45859
24	11	UD5009	71913	45563
24	12	AN3055	73171	46086
24	16	UD4030	71308	47347
24	19	AN3077	71812	45669

Table 1 (Cont.)

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
24	24	UD4136	70103	30045
24	27	AN3129	71442	41286
24	28	XN2068	61682	42817
25	4	AN3013	71838	47089
25	5	AN3102	71753	36910
25	6	AN3012	5999D	37819
25	8	UD5020	71791	44261
25	9	AN3088	5905D	35518
25	14	UD5008	71377	46817
25	15	UD4028	73368	30426
25	22	AN3094	5852D	38237
25	25	AN3059	5868D	35158
25	26	AN3065	71976	39663
25	27	AN3005	73153	47029
25	28	AN3006	71912	47221
26	5	AN3044	73422	44510
26	11	AN3087	61578	47363
26	18	UD5034	71771	44582
26	20	AN3105	70206	47141
26	26	AN3047	73133	41869
27	6	AN3101	61523	47454
27	7	AN3018	71431	41309
27	10	UD4011	71792	30625
27	12	UD4137	62501	30375
27	14	UD4006	71954	31509
27	16	UD5038	71960	43602
27	19	UD4141	71369	30376
27	21	UD4132	63950	30900
27	25	AN3108	71994	47321
28	7	XN2081	71390	36125
28	15	XN2073	71964	40563
28	16	XN2060	73416	33610
28	24	XN2078	61673	42327
28	25	AN3017	73139	47186
29	20	UD5032	70243	42458
29	23	AN3109	73121	47750
30	9	AN3127	70102	46819
30	10	AN3071	73131	35907
30	11	AN3132	71981	46882
30	12	AN3072	71788	47029
30	13	AN3114	5805D	34826
30	14	AN3014	71985	44707
30	15	XN2065	71921	32884
30	16	XN2052	61526	32863
30	17	AN3015	72014	44802
30	18	AN3106	5932D	37651

Table 1 (Cont.)

Row	Column	Current Assembly	Channel ID	Proj. EOC 9 Exposure
30	19	AN3110	71773	46884
30	20	AN3024	71445	47032
30	21	AN3115	73227	47512
30	22	AN3062	71890	46812

Figure 1
Cycle 9 Load Pattern Showing Assemblies with Reused Channels

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1									AN3042*	AN3075*	AN3033*	AN3067*	AN3066*	AN3036*	XN2087*
2								AN3068*	UD6038	UD4018	UD5124	UD6069	UD6059	UD5093	UD6039
3						AN3040*	XN2091*	UD6113	UD4034*	WP8	UD6068	WP8	UD7030	WP8	XN2025
4						AN3099*	AN3064*	UD6075	WP8	UD4115*	UD7095	UD4114	WA6003	UD4032*	UD5128
5					AN3031*	UD4146	UD6054	WP8	UD7078	WP8	AN3074*	WP8	UD5066*	WP8	UD7075
6			AN3038*	AN3051*	AN3133*	AN3043*	UD6120	UD5071*	AN3092*	UD5064*	UD6087	UD6013	UD6028	UD5061	UD4082
7			XN2086*	AN3046	UD6056	UD6112	UD4112	UD5070*	UD7021	WP8	UD5058	AN3039*	UD7064	WP8	UD4051
8		AN3034*	UD6058	UD6053	WP8	UD5129	UD5135	UD5072*	UD6061	AN3070*	UD4025*	UD5063*	UD5125	UD4118	UD5122
9	AN3032*	UD6052	UD4122	WP8	UD7024	AN3104*	UD7089	UD6062	UD4128	WP8	UD4108	WP8	UD5062	WP8	UD5005
10	AN3076*	UD4111	WP8	UD4024*	WP8	LYV153	WP8	AN3079*	WP8	UD4045	WP8	UD4048	UD7087	UD4107	UD4103
11	AN3100*	UD5121	UD6041	UD7005	AN3053*	UD6037	UD5126	UD4121	UD4117	WP8	UD4100	UD5131	UD7093	WP8	UD5057
12	AN3052*	UD6057	WP8	UD4017	WP8	UD6060	AN3069*	UD5132	WP8	UD4047	UD5123	UD4043	UD6108	UD4099	AN3035*
13	AN3054*	UD6114	UD7068	UD5111	UD5127	UD6036	UD7090	UD5065*	UD5055	UD7020	UD7023	UD6103	UD4053	WP8	UD6026
14	AN3080*	UD5054	WP8	UD4054	WP8	UD5087	WP8	UD4052	WP8	UD4113	WP8	UD4104	WP8	UD7079	UD4044
15	XN2084*	UD6115	XN2024	UD5130	UD7019	UD4062	UD4088	UD5030*	UD5007	UD4061	UD5056	AN3041*	UD6094	UD4046	UD5069*
16	XN2066*	UD6002	XN2071	UD5040*	UD7011	UD4016*	UD4021*	UD5042	UD5019	UD4143*	UD5036*	AN3020*	UD6117	UD4102	UD5028*
17	AN3002*	UD5075	WP8	UD4097	WP8	UD5134	WP8	UD4091	WP8	UD4144*	WP8	UD4012*	WP8	UD7063	UD4098
18	AN3058*	UD6012	UD7053	UD5086	UD5080	UD6034	UD7072	UD5095	UD5039*	UD7062	UD7047	UD6022	UD4095	WP8	UD6102
19	AN3019*	UD6078	WP8	UD4077	WP8	UD6080	AN3010	UD5103	WP8	UD4005*	UD5010*	UD4101	UD6016	UD4039*	AN3056*
20	AN3086*	UD5085	UD6015	UD7031	AN3057*	UD6100	UD5094	UD4072	UD4033*	WP8	UD4041*	UD5004*	UD7001	WP8	UD5016*
21	AN3073*	UD4042*	WP8	UD4076	WP8	LYV156	WP8	AN3128*	WP8	UD4038*	WP8	UD4015*	UD7010	UD4027*	UD4040*
22	AN3123*	UD6079	UD4071	WP8	UD7065	AN3050*	UD7046	UD6021	UD4131	WP8	UD4026*	WP8	UD5014*	WP8	UD5003
23		AN3011*	UD6077	UD6110	WP8	UD5078	UD5102	UD5011*	UD6029	AN3131*	UD4087	UD5084	UD5079	UD4116*	UD5018*
24			XN2056*	AN3037*	UD6072	UD6001	UD4138*	UD5017*	UD7060	WP8	UD5009*	AN3055*	UD7083	WP8	UD4092
25			AN3009	AN3013*	AN3102*	AN3012*	UD6017	UD5020*	AN3088*	UD5076	UD6105	UD6071	UD6035	UD5008*	UD4028*
26					AN3044*	UD4145	UD6067	WP8	UD7080	WP8	AN3087*	WP8	UD5082	WP8	UD7004
27						AN3101*	AN3018*	UD6111	WP8	UD4011*	UD7054	UD4137*	WA6001	UD4006*	UD5077
28						AN3118	XN2081*	UD6073	UD4094	WP8	UD6055	WP8	UD7013	WP8	XN2073*
29								AN3113	UD6014	UD4078	UD5081	UD6070	UD6076	UD5120	UD6018
30									AN3127*	AN3071*	AN3132*	AN3072*	AN3114*	AN3014*	XN2065*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	XN2095*	AN3008*	AN3095*	AN3098*	AN3021*	AN3107*	AN3025*								
2	UD6066	UD5083	UD6050	UD6063	UD5052	UD4058	UD6065	AN3096*							
3	XN2108*	WP8	UD7027	WP8	UD6019	WP8	UD4059	UD6119	XN2099*	AN3126*					
4	UD5068	UD4055	WA6004	UD4127	UD7067	UD4105	WP8	UD6096	AN3028*	AN3045*					
5	UD7103	WP8	UD5115	WP8	AN3090*	WP8	UD7082	WP8	UD6046	UD4147	AN3029*				
6	UD4093	UD5044	UD6049	UD6047	UD6010	UD5073	AN3089*	UD5043	UD6101	AN3083*	AN3134*	AN3119*	AN3130*		
7	UD4065	WP8	UD7077	AN3125*	UD5109	WP8	UD7043	UD5050	UD4109	UD6099	UD6040	AN3124*	XN2094*		
8	UD5116	UD4126	UD5108	UD5049	UD4073	AN3027*	UD6064	UD5091	UD5046	UD5048	WP8	UD6097	UD6109	AN3022*	
9	UD5015	WP8	UD5045	WP8	UD4124	WP8	UD4130	UD6044	UD7025	AN3085*	UD7018	WP8	UD4096	UD6043	AN3030*
10	UD4119	UD4129	UD7091	UD4010	WP8	UD4020	WP8	AN3084*	WP8	LYV155	WP8	UD4022*	WP8	UD4110	AN3097*
11	UD5041	WP8	UD7105	UD5117	UD4001	WP8	UD4123	UD4031*	UD5118	UD6011	AN3103*	UD7040	UD6048	UD5047	AN3049*
12	AN3007*	UD4120	UD6042	UD4064	UD5051	UD4019	WP8	UD5119	AN3081*	UD6045	WP8	UD4066	WP8	UD6025	AN3120*
13	UD6020	WP8	UD4070	UD6107	UD7032	UD7099	UD5053	UD5067	UD7022	UD6104	UD5113	UD5133	UD7094	UD6106	AN3082*
14	UD4063	UD7033	WP8	UD4106	WP8	UD4050	WP8	UD4029*	WP8	UD5013*	WP8	UD4069	WP8	UD5110	AN3001*
15	UD5112	UD4057	UD6074	AN3026*	UD5074	UD4009	UD5012	UD5035*	UD4125	UD4056	UD7102	UD5114	XN1090	UD6098	XN2067*
16	UD5025*	UD4084	UD6081	AN3060*	UD5022*	UD4140*	UD5027	UD5060	UD4003*	UD4139*	UD7066	UD5101	XN1141	UD6030	XN2100*
17	UD4080	UD7088	WP8	UD4134*	WP8	UD4142*	WP8	UD4081	WP8	UD5136	WP8	UD4067	WP8	UD5026*	AN3122*
18	UD6116	WP8	UD4068	UD6027	UD7100	UD7056	UD5031*	UD5021*	UD7016	UD6006	UD5105	UD5092	UD7057	UD6008	AN3112*
19	AN3078*	UD4007*	UD6009	UD4079	UD5024*	UD4014*	WP8	UD5090	AN3023*	UD6093	WP8	UD4086	WP8	UD6088	AN3063*
20	UD5037*	WP8	UD7084	UD5106	UD4036*	WP8	UD4023*	UD4075	UD5033*	UD6118	AN3111*	UD7106	UD6085	UD5023*	AN3091*
21	UD4035*	UD4008*	UD7097	UD4013*	WP8	UD4083*	WP8	AN3016*	WP8	LYV154	WP8	UD4060	WP8	UD4135*	AN3116*
22	UD5006	WP8	UD5100	WP8	UD4037*	WP8	UD4133	UD6032	UD7096	AN3093*	UD7058	WP8	UD4089	UD6092	AN3048*
23	UD5002	UD4004*	UD5107	UD5001	UD4090	AN3121*	UD6023	UD5089	UD5088	UD5029*	WP8	UD6086	UD6089	AN3061*	
24	UD4030*	WP8	UD7050	AN3077*	UD5104	WP8	UD7055	UD5099	UD4136*	UD6003	UD6084	AN3129*	XN2068*		
25	UD4049	UD5096	UD6005	UD6024	UD6082	UD5097	AN3094*	UD5098	UD6007	AN3059*	AN3065*	AN3005*	AN3006*		
26	UD7081	WP8	UD5034*	WP8	AN3105*	WP8	UD7026	WP8	UD6083	UD4148	AN3047*				
27	UD5038*	UD4002	WA6002	UD4141*	UD7052	UD4132*	WP8	UD6051	AN3117	AN3108*					
28	XN2060*	WP8	UD7035	WP8	UD6090	WP8	UD4074	UD6095	XN2078*	AN3017*					
29	UD6031	UD5059	UD6091	UD6033	UD5032*	UD4085	UD6004	AN3109*							
30	XN2052*	AN3015*	AN3106*	AN3110*	AN3024*	AN3115*	AN3062*								
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

WP8 are fresh 9x9-9X assemblies loaded in Cycle 9
* Assemblies with Reused Channels

50-397

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

November 10, 1992

NRC INFORMATION NOTICE 92-74: POWER OSCILLATIONS AT WASHINGTON NUCLEAR POWER UNIT 2

Addressees

All holders of operating licenses or construction permits for boiling-water reactors (BWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a recent event involving power oscillations in an operating region where instability had not been specifically predicted. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Background

On March 9, 1988, a thermal hydraulic instability event occurred at LaSalle Unit 2. The NRC discussed this event in Information Notice 88-39, "LaSalle Unit 2 Loss of Recirculation Pumps with Power Oscillation Event," and Bulletins 88-07 and 88-07, Supplement 1, "Power Oscillations in Boiling Water Reactors." In the first bulletin, the NRC requested licensees to establish procedures and give training to reactor operators to enable them to recognize oscillations and to take appropriate actions. In the supplement, the NRC requested licensees to implement the General Electric (GE) Interim Recommendations for Stability Actions, designated the Interim Corrective Actions (ICA). GE defined the exclusion regions on the power/flow map in which, with varying probability, instability might be expected. Three regions were defined in which operation was to be avoided (immediate exit if entered) or limited (e.g., when required during startup). These regions were based on operating or test experience for reactors with GE fuel. The exclusion regions for new fuel designs were to be reevaluated and justified based on any applicable operating experience, calculated changes in core decay ratio using NRC-approved methodology, and/or core decay ratio measurements. Since the LaSalle event in 1988, the NRC and the BWR Owners' Group (BWROG) have conducted extensive analyses and reviews of various aspects of stability while developing long-term solutions to augment or replace the ICA. On March 18, 1992, the BWROG sent a letter (BWROG-92030) to BWROG members

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transmitting "Implementation Guidance for Stability Interim Corrective Actions." In this letter, the BWROG emphasized the need for caution when operating near the exclusion regions. The BWROG also recommended reexamining procedures and training to reflect uncertainties in the definition of exclusion region boundaries.

Description of Circumstances

On August 15, 1992, Washington Nuclear Power Unit 2 (WNP-2) experienced power oscillations during startup. The event occurred early in cycle 8 operation. During cycle 8, the licensee had two previous startups without incident. The reactor core consisted primarily of Siemens fuel, with about 74 percent of this fuel in 8x8 fuel assemblies and about 25 percent in 9x9 fuel assemblies, and with the remainder of the core consisting of various lead test assemblies. The 9x9 fuel assembly used in WNP-2, designated 9x9-9x, has a higher flow resistance than the 8x8 fuel assembly with a difference of about 10 percent in pressure drop. These 9x9 fuel assemblies were loaded during cycles 7 and 8.

About 33 hours before the event, the licensee commenced a controlled power reduction from full power to 5-percent power to repair a valve packing leak in the drywell. After completing the repairs, the licensee began a return to full power. The licensee increased reactor power to about 34 percent and then held it at that level for 3 hours to perform turbine bypass valve tests and control rod drive system timing tests. The recirculation system was operated with flow control valves (FCVs) full open and pumps at slow speed.

After completing the tests, the operators continued the restart up the (approximately) 30-percent flow line to about 36-percent power (Figure 1). This is at a power above the recirculation pump cavitation region. The operators then began closing one of the two FCVs in preparation for shifting the associated recirculation pump to fast speed. During this change, in which power and flow decreased along the 76-percent rod line to a power/flow of about 34/27 percent, the operators observed power oscillations first on the average power range monitors (APRMs) and then by local power range monitors (LPRMs) downscale indications. Upon recognizing the power oscillations, the plant operators manually initiated a reactor scram. Post-event review indicated that the 2-second-period oscillations were in-phase (core-wide) and had grown to a peak-to-peak amplitude of about 25 percent of rated power. Most of the oscillation amplitude increase occurred in an interval of about 1 minute with the oscillations continuing at the limiting (maximum) amplitude for an additional minute before scram. The oscillations occurred while the reactor was operating at a power about 4 percent of rated power below the lower exclusion region boundary line (the nominal 80-percent rod line). During later review, the licensee found no indication that fuel had failed because of the event.

The NRC sent an Augmented Inspection Team (AIT) to the site to determine the possible causes and relevant facts of this event. The AIT concluded that the primary cause of the oscillations was very skewed radial and bottom peaked axial power distributions in the reactor (1.92 radial peaking factor and 1.62 core average axial peaking factor). These power distributions resulted from (1) the control rod pattern that the shift technical advisor selected for increasing the power and shifting the recirculation pump speed, and (2) the relationship of this control rod pattern to the specific WNP-2 cycle 8 core fuel loading configuration. These rod patterns were primarily directed towards achieving the target full power configuration and did not consider stability concerns.

The AIT also found, by analyses using the LAPUR code, that a contributor to the oscillations was the core loading, consisting of a mixed core with unbalanced flow characteristics between the new 9x9-9x fuel and the old 8x8 fuel. The analyses indicated that a full core of the 9x9-9x fuel would be significantly less stable than the old 8x8 fuel, and that the mixed core was less stable than a fully loaded core of either fuel type. The analyses also indicated that while the oscillations would be in-phase (core-wide), as observed in the event, the out-of-phase (regional) instability boundary would be very close to the in-phase boundary (Figure 1). The AIT found that small changes in operating conditions could have resulted in out-of-phase oscillations, which would have been more difficult for the APRM system to detect.

WNP-2 has a Siemens Advanced Neutron Noise Analysis (ANNA) monitor, a stability monitor required by technical specifications only if the licensee intends to enter the lower exclusion region. Since the licensee did not intend to enter the exclusion region during this startup, the ANNA monitor was not put into the observation mode, although it was gathering data which was used later to confirm stability calculations performed after the event.

The licensee successfully restarted the unit after implementing the following restrictions for maintaining the limits on rod withdrawal patterns and power distribution in the low flow regions of concern.

- The licensee analyzed the control rod patterns for stability before startup, and the operator could not change these patterns without analysis and review.
- The calculated maximum total peaking factor was less than 3.4.

- The calculated core average axial peaking factor was less than 1.45.
- The Minimum Critical Power Ratio was greater than 2.2.
- The licensee analyzed the conditions at FCV closure and found a decay ratio of less than 0.5. The recirculation pump was shifted to fast speed with the reactor power less than 33 percent and the feedwater temperature greater than 146.1 °C (295 °F).
- The licensee continuously used the ANNA monitor when the reactor was operating above 25 percent power and below 50 percent flow.

Further detailed description of the event can be found in the AIT Inspection Report No. 50-397/92-30.

Discussion

The WNP-2 power oscillation event indicates that the boundaries of the ICA regions, or modifications approved for various reactor technical specifications, do not necessarily encompass all stability limits. Instability may occur beyond these boundaries if the reactor is operated with configurations outside those used to define the boundaries. This event presented direct evidence that the following factors can be significant contributors to the possibility of unstable operation.

- Power distributions involving extremely skewed radial and axial peaking factors can induce unstable operation even in regions or with operating conditions not otherwise considered susceptible to oscillations.
- Core loading patterns involving a mixture of fuel types with differing flow resistances can contribute to instability.
- Reactors with two-speed recirculation pumps and FCVs can hinder stability because of the narrow range of operation between pump cavitation regions and possible instability regions.

The event also indicates the value of operating a stability monitor. The ANNA monitor could have given the operators information that instability was imminent, prompting them to alter operations to avoid the oscillations.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
Division of Operating Reactors Support
Office of Nuclear Reactor Regulation

Technical contacts: Howard Richings, NRR
(301) 504-2888

Peter C. Wen, NRR
(301) 504-2832

Attachments:
1. Figure 1. Best-Estimate Lines of Constant Decay Ratio=1.0 for Actual Conditions of WNP-2 8/15/1992 Event, Assuming Constant Power Distribution
2. List of Recently Issued NRC Information Notices

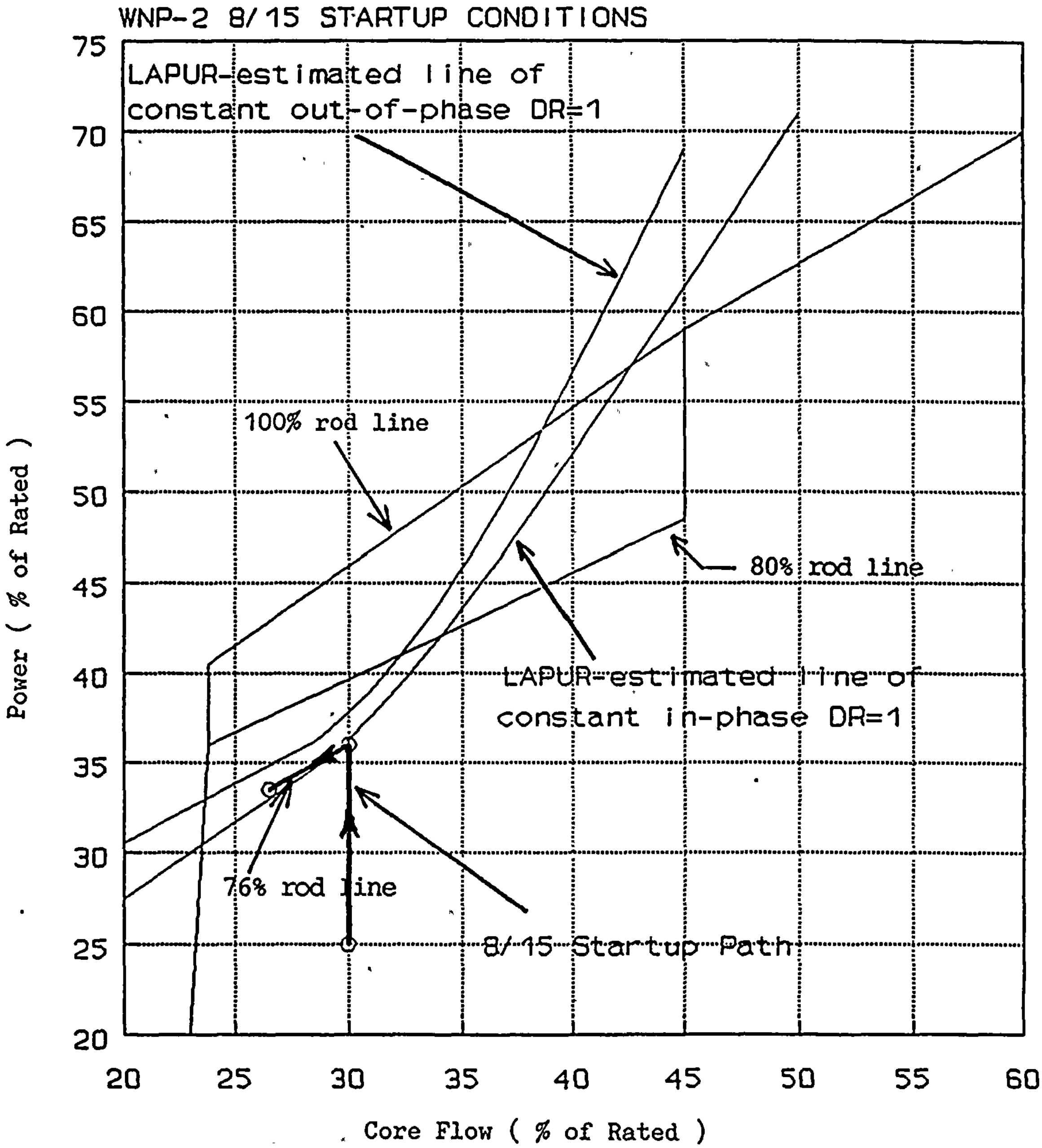

Figure 1. Best-estimate lines of constant decay ratio=1.0 for actual conditions of 8/15 event, assuming constant power distribution

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
92-61, Supp. 1	Loss of High Head Safety Injection	11/06/92	All holders of OLs or CPs for nuclear power reactors.
92-73	Removal of A Fuel Element from A Research Reactor Core While Critical	11-04/92	All holders of OLs or CPs for nuclear power reactors.
92-59, Rev. 1	Horizontally-Installed Motor-Operated Gate Valves	11/04/92	All holders of OLs or CPs for nuclear power reactors.
92-72	Employee Training and Shipper Registration Requirements for Transporting Radioactive Materials	10/28/92	All U.S. Nuclear Regulatory Commission Licensees.
91-64, Supp. 1	Site Area Emergency Resulting from A Loss of Non-Class 1E Uninterruptible Power Supplies	10/07/92	All holders of OLs or CPs for nuclear power reactors.
92-71	Partial Plugging of Suppression Pool Strainers At A Foreign BWR	09/30/92	All holders of OLs or CPs for nuclear power reactors.
92-70	Westinghouse Motor-Operated Valve Performance Data Supplied to Nuclear Power Plant Licensees	09/25/92	All holders of OLs or CPs for nuclear power reactors.
92-69	Water Leakage from Yard Area Through Conduits Into Buildings	09/22/92	All holders of OLs or CPs for nuclear power reactors.
91-29, Supp. 1	Deficiencies Identified During Electrical Distribution System Functional Inspections	09/14/92	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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