NF-BEX-06-167 Rev. 2 NP-Attachment

Dresden Unit 3 Cycle 20 SLMCPR

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1.0 Introduction

This document contains a description of the safety limit minimum critical power ratio (SLMCPR) evaluation for Dresden 3 (DNPS3) Cycle 20, as well as identification of the critical power ratio (CPR) correlation for Global Nuclear Fuel (GNF) GE14 fuel and the "conservative Adder" required by SER restriction 7 of Reference 3. As discussed below, dual and single recirculation loop SLMCPRs of 1.10 and 1.11, respectively, will be applied to the GE14 fuel in Dresden 3 Cycle 20. Dual and single recirculation loop SLMCPRs of 1.12 and 1.14, respectively, have been calculated for the Westinghouse SVEA-96 Optima2 assemblies in Dresden 3 Cycle 20.

The GNF NRC-approved methodology (References 1 and 2) was used previously to determine the appropriate SLMCPR values for the currently operating DNPS3 Cycle 19, which contains GNF GE14 and Framatome-ANP (FANP) ATRIUM-9B fuel assemblies. Consistent with the GNF methodology, the resulting Cycle 19 SLMCPRs apply to all fuel types in the core, such that the same SLMCPRs are applied to both the GE14 and ATRIUM-9B fuel assemblies.

For D3 Cycle 20, Exelon Generation Company, LLC (EGC) will load Westinghouse SVEA-96 Optima2 fuel. Therefore, the Westinghouse NRC-approved methodology described in Reference 3 and further clarified in the response to request for additional information (RAI) D13 of Reference 4, was used to determine the SLMCPRs for Cycle 20. Further clarification of the Westinghouse SLMCPR methodology was also provided to the NRC in support of the transition to SVEA-96 Optima2 fuel in the Quad Cities and Dresden Units as follows:

> The response to NRC Request 19 in Reference 9 which supported the Licensing Amendment Request for transition to SVEA-96 Optima2 fuel in the Dresden and Quad Cities plants provided in Reference 8,
>
> The technical information supporting the Quad Cities 2 Technical Specification SLMCPR changes transmitted by Reference 10 as supplemented by the clarifying information in Reference 11.

The same SLMCPR methodology described in these references was followed for the DNPS3 Cycle 20 SLMCPR evaluations. Unlike the GNF methodology, [

]a,c

The EGC proposed license amendment to use the Westinghouse methodology for core reload evaluations at the Dresden and Quad Cities units was submitted to the NRC in Reference 8. This submittal was approved by the NRC and supported the QC2 startup with a reload core containing SVEA-96 Optima2 fuel (i.e., Cycle 19). It also supports the DNPS3 Cycle 20 with a reload core containing SVEA-96 Optima2 fuel.

Condition 7 in the NRC safety evaluation for Reference 3 requires that a conservative factor applied to the GE14 operating limit minimum critical power ratio (OLMCPR) be identified in licensee applications. The value of this factor for DNPS3, Cycle 20, is [ ]^{a,c} which was also used for the QC2 Cycle 19 licensing analysis.

2.0 GE14 SLMCPR for DNPS3 Cycle 20

Consistent with the Westinghouse methodology described in Reference 3, the treatment of the SLMCPR in mixed cores containing non-Westinghouse fuel [ ]^{a,c} DNPS3 Cycle 19 contained 524 GE14 fuel assembles and 200 ATRIUM-9B fuel assemblies. As shown in Figure 2, all of the ATRIUM-9B fuel assemblies were in their third cycle of operation in Cycle 19 and were loaded on or near the core periphery (within the outer four rows), while the GE14 fuel was loaded in the central part of the core. Therefore, the Atrium fuel CPRs were substantially greater than those for the GE14 fuel and the SLMCPR for Cycle 19 was established by contributions from the GE14 fuel assemblies. [ ]^{a,c} The Cycle 19 SLMCPR was determined by GNF based on plant- and cycle-specific analyses using GNF's NRC-approved methodology and uncertainties (References 1 and 2) as supplemented with DNPS3-specific uncertainties. The GNF evaluation used the GEXL14 correlation for GE14 fuel. The GNF evaluation confirmed that the dual-loop and single-loop SLMCPRs of 1.10 and 1.11, respectively, in Reference 5 bounded the calculated Cycle 19 results and, therefore, continued to be appropriate for Cycle 19. [ ]^{a,c} A comparison between the Cycle 19 and 20 cores is shown in Table 1.

3.0 SVEA-96 Optima2 SLMCPR for Cycle 20

In establishing the SLMCPR for Westinghouse SVEA-96 Optima2 fuel assemblies, it is assumed that [ ]^{a,c}

[ ]^{a,c} a Reference Core design (SVEA-96 Optima2 bundle designs, core loading pattern and state point depletion strategy) that represents realistic current plans for the Cycle 20 loading and operation. The Reference Core loading pattern for Cycle 20 is shown in Figure 1. The Reference Core design was generated via collaboration between EGC and Westinghouse based on EGC's cycle assumptions and design goals. The Reference Core was designed to meet the cycle energy requirements, to satisfy all licensing requirements, to provide adequate thermal margins and

operational flexibility, and to meet other design and manufacturing criteria established by EGC and Westinghouse.

In general, the calculated SLMCPR is dominated by the flatness of the assembly CPR distribution across the core and the flatness of the relative pin CPR distribution based on the pin-by-pin power/R-factor distribution in each bundle. Greater flatness in either parameter yields more rods susceptible to boiling transition and thus a higher SLMCPR.

The calculation of the SLMCPR as a function of cycle exposure captures the interplay between the relative fuel assembly CPR and bundle relative pin-by-pin CPR distributions established from the power/R-factor distributions and allows a determination of the maximum (limiting) SLMCPR for the entire cycle. This limiting SLMCPR is applied throughout the entire cycle.

The SVEA-96 Optima2 SLMCPR for DNPS3 Cycle 20 was determined as a function of cycle exposure based on radial assembly power distributions at least as flat as the cycle exposure-dependent radial power distributions from [

]a,c

Accordingly, the SVEA-96 Optima2 SLMCPR for dual recirculation loop (DLO) operation was calculated at 100% power and 100% flow at 15 cycle exposures throughout the cycle to assure that the limiting SLMCPR was identified. In addition, the dual recirculation loop SLMCPRs were calculated at 100% power at the minimum allowed core flow at rated power (95.3% flow) and a maximum core flow at rated power of 108% flow at the maximum 100% core flow SLMCPR cycle burnup point to confirm that a limiting SLMCPR had been established. Figure 3 shows a current DNPS3 power-to-flow map which is applicable to Cycle 20. While, as shown in Figure 3, DNPS3 Cycle 20 is not licensed for a maximum core flow of 108 %, a flow window 95.3% to 108 % of rated core flow was analyzed.

Single recirculation loop (SLO) SVEA-96 Optima2 SLMCPR calculations were also performed. These SLMCPR calculations were performed at [

]a,c The single loop calculations used the same procedure as the dual loop cases, except that the single loop cases applied a larger uncertainty for the core flow.

The SLMCPR results for Cycle 20 are plotted in Figure 4. As shown in Figure 4, the dual recirculation loop SLMCPR [

]^{a,c} the interplay between the assembly relative CPRs and the relative fuel rod CPRs. In general, as the fraction of assembly or fuel rod CPRs in the vicinity of the minimum assembly or fuel rod CPR increases, the number of rods with a potential for experiencing dryout increases. Therefore, a larger SLMCPR is required to assure that less than 0.1% of the rods are in dryout.

While control rod patterns at individual state points required to maintain margins to thermal limits may perturb the trend, experience has shown that the assembly CPR distributions tend to become [

]^{a,c} Therefore, the peak SLMCPR tends to occur when the assembly CPR and rod CPR distributions combine to place the maximum number of fuel rod CPRs close to the minimum CPR.

This behavior is shown for the DNPS3, Cycle 20 SLMCPR by the relative assembly CPR and relative fuel rod histograms shown in Figures 5 through 15 and 16 through 25, respectively. In Figures 5 through 15, assembly types RA20, RB20, and RC20 refer to the SVEA-96 Optima2 assembly types loaded in Cycle 20. Assembly type [

]^{a,c}

Inspection of the DLO histograms in Figures 5 through 15 and the relative fuel rod CPR histograms in Figures 16 through 25 leads to the following observations, which explain the SLMCPR behavior in Figure 4:

1. [

]a,c

Therefore, the dual recirculation loop SLMCPR results at rated conditions in Figure 4 can be explained in terms of [

]a,c

As noted above, the continued adequacy of a dual recirculation loop SLMCPR of [

]a,c

The single recirculation loop (SLO) results calculated at [

]a,c

In addition to the strong dependence on assembly CPR and relative fuel rod CPR distributions, the SLMCPR is strongly dependent on the distribution of assembly and relative fuel pin CPRs about their mean values leading to an overall distribution of fuel rod CPRs relative to their

mean values. The wider these distributions, the higher the SLMCPR must be to prevent 0.1% of the fuel rods from experiencing boiling transition. The distributions of fuel rod CPRs relative to their mean values are determined by the uncertainties relative to the mean CPRs. Accordingly, the uncertainties used in establishing the SVEA-96 Optima2 SLMCPR for Cycle 20 are shown in Table 2.

4.0 Westinghouse CPR Correlation for GE14 Fuel

The Westinghouse CPR correlation for GE14 fuel used in the DNPS3 reload design and licensing analyses is the same as that used for QC2 Cycle 19 and described in the Response to NRC Request 8 in Reference 9. Further clarification of the correlation was provided in the response to NRC Request 2 in Reference 11 as well as in Reference 12.

[

]^{a,c} The determination of this value was also based on EGC's plans to continue to monitor the CPR performance of GE14 fuel using the GNF GEXL14 correlation within the POWERPLEX-III online core monitoring system rather than the USAG14 correlation. This approach is consistent with Westinghouse's NRC-approved methodology per Reference 3.

5.0 References

1. Letter, Frank Akstulewicz (NRC) to Glen A. Watford (GE), "Acceptance for Referencing of Licensing Topical Reports NEDC-32601P, Methodology and Uncertainties for Safety Limit MCPR Evaluations; NEDC-32694P, Power Distribution Uncertainties for Safety Limit MCPR Evaluation; and Amendment 25 to NEDE-24011-P-A on Cycle Specific Safety Limit MCPR," (TAC Nos. M97490, M99069, and M97491), March 11, 1999.
2. General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation, and Design Application, NEDO-10958-A, January 1977.
3. Licensing Topical Report, Reference Safety Report for Boiling Water Reactor Reload Fuel, CENPD-300-P-A, July 1996.
4. CENPD-389-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlations: SVEA-96+, August 1999.
5. Dresden Technical Specifications, Section 2.1.1.2
6. WCAP-16081-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2, March 2005.
7. Letter, Jason S. Post (GE) to NRC, Part 21 60 Day Interim Report Notification: Critical Power Determination for GE14 and GE12 Fuel With Zircaloy Spacers, MFN 05-058 Rev 1, June 24, 2005, and GE Energy – Nuclear, 10 CFR Part 21 Communication, 60-Day Interim Report Notification and Transfer of Information, Critical Power Determination for GE14 and GE12 Fuel With Zircaloy Spacers, SC05-04 Rev 1, June 24, 2005.
8. Letter, Patrick R. Simpson (Exelon Generation Company, LLC) to NRC, Request for License Amendment Regarding Transition to Westinghouse Fuel, dated June 15, 2005.

9. RS-06-009, Additional Information Supporting Request for License Amendment Regarding Transition to Westinghouse Fuel, January 26, 2006.
10. Letter from Patrick R. Simpson, Exelon Nuclear, to U.S. NRC, "Request for Technical Specifications Change for Minimum Critical Power Ratio Safety Limit", QCNPS, Unit 2, December15, 2005.
11. RS-06-024, "Additional Information Supporting Request for Technical Specifications Change for Minimum Critical Power Ratio Safety Limit", QCNPS, Unit 2, February 13, 2006.
12. RS-06-038, "Additional Information Supporting Request for Licensing Amendment Request Regarding Transition to Westinghouse Fuel and Request for Technical Specifications Change for Minimum Critical Power Ratio Safety Limit", March 3, 2006.

Table 1 Comparison of Cycle 19 and 20 Cores

Description	Dresden 3 Cycle 19	Dresden 3 Cycle 20
Number of Bundles in Core	724	724
Limiting Cycle Exposure Point	N/A (GNF proprietary)	Near EOC
Cycle Exposure at Limiting Point, EFPH	N/A (GNF proprietary)	12,989 EFPH
Reload Fuel Type	GE14	SVEA-96 Optima2
Reload Batch Average Weight % Enrichment	3.98 w/o	3.90 w/o
Reload Batch Fraction (%)	33.1%	33.7%
Batch Fraction of SVEA-96 Optima2 Fuel	00.0%	33.7%
Batch Fraction of GNF GE14 Fuel	72.4%	66.3%
Batch Fraction of FANP ATRIUM-9B Fuel	27.6%	00.0%
Core Average Weight % Enrichment	3.96 w/o	3.99 w/o
Calculated Safety Limit MCPR (DLO)	1.10 for all fuel types	[ ]a,c
Calculated Safety Limit MCPR (SLO)	1.11 for all fuel types	[ ]a,c

Table 2 - Uncertainties used in Dresden 3 Cycle 20 SVEA-96 Optima2 SLMCPR Determination

a,c

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60											4	3	4	3	3	3	3	4	3	4										
58										4	4	3	3	3	3	3	3	3	3	4	4									
56							4	3	4	3	3	7	9	9	9	9	9	9	7	3	3	4	3	4						
54						4	4	4	4	3	9	9	7	5	3	3	5	7	9	9	3	4	4	4	4					
52					3	3	4	3	9	6	3	6	5	8	6	6	8	5	6	3	6	9	3	4	3	3				
50				4	3	3	4	9	6	5	6	5	8	3	4	4	3	8	5	6	5	6	9	4	3	3	4			
48			4	3	4	4	9	6	7	6	7	7	5	8	7	7	8	5	7	7	6	7	6	9	4	4	3	4		
46			3	3	3	9	6	7	7	7	8	7	6	7	6	6	7	6	7	8	7	7	7	6	9	3	3	3		
44			4	4	9	6	7	7	7	8	7	8	7	6	7	7	6	7	8	7	8	7	7	7	6	9	4	4		
42		4	3	3	6	5	6	7	8	7	6	7	8	5	6	6	5	8	7	6	7	8	7	6	5	6	3	3	4	
40	4	3	3	9	3	6	7	8	7	6	7	7	7	6	7	7	6	7	7	7	6	7	8	7	6	3	9	3	3	4
38	4	3	7	9	6	5	7	7	8	7	7	8	7	7	8	8	7	7	8	7	7	8	7	7	5	6	9	7	3	4
36	4	3	9	7	5	8	5	6	7	8	7	7	8	7	7	7	7	8	7	7	8	7	6	5	8	5	7	9	3	4
34	4	3	9	5	8	3	8	7	6	5	6	7	7	7	8	8	7	7	7	6	5	6	7	8	3	8	5	9	3	4
32	3	3	9	3	6	4	7	6	7	6	7	8	7	8	7	7	8	7	8	7	6	7	6	7	4	6	3	9	3	3
30	3	3	9	3	6	4	7	6	7	6	7	8	7	8	7	7	8	7	8	7	6	7	6	7	4	6	3	9	3	3
28	4	3	9	5	8	3	8	7	6	5	6	7	7	7	8	8	7	7	7	6	5	6	7	8	3	8	5	9	3	4
26	4	3	9	7	5	8	5	6	7	8	7	7	8	7	7	7	7	8	7	7	8	7	6	5	8	5	7	9	3	4
24	4	3	7	9	6	5	7	7	8	7	7	8	7	7	8	8	7	7	8	7	7	8	7	7	5	6	9	7	3	4
22	4	3	3	9	3	6	7	8	7	6	7	7	7	6	7	7	6	7	7	7	6	7	8	7	6	3	9	3	3	4
20		4	3	3	6	5	6	7	8	7	6	7	8	5	6	6	5	8	7	6	7	8	7	6	5	6	3	3	4	
18			4	4	9	6	7	7	7	8	7	8	7	6	7	7	6	7	8	7	8	7	7	7	6	9	4	4		
16			3	3	3	9	6	7	7	7	8	7	6	7	6	6	7	6	7	8	7	7	7	6	9	3	3	3		
14			4	3	4	4	9	6	7	6	7	7	5	8	7	7	8	5	7	7	6	7	6	9	4	4	3	4		
12				4	3	3	4	9	6	5	6	5	8	3	4	4	3	8	5	6	5	6	9	4	3	3	4			
10					3	3	4	3	9	6	3	6	5	8	6	6	8	5	6	3	6	9	3	4	3	3				
8						4	4	4	4	3	9	9	7	5	3	3	5	7	9	9	3	4	4	4	4					
6							4	3	4	3	3	7	9	9	9	9	9	9	7	3	3	4	3	4						
4										4	4	3	3	3	3	3	3	3	3	4	4									
2											4	3	4	3	3	3	3	4	3	4										

Designation	Bundle Type	Bundle Name	# Assem	ID Range	Cycle First Loaded
6	Optima2	Opt2-3.90-10G8.00/6.00-4GZ8.00-2G6.00	104	DSA061-DSA164	20
8	Optima2	Opt2-3.88-10G8.00/6.00-6GZ8.00-2G6.00	80	DSA165-DSA244	20
9	Optima2	Opt2-3.93-14GZ6.00	60	DSA001-DSA060	20
3	GE14	GE14-P10DNAB411-4G7.0/9G6.0-100T-145-T6-2553	140	JLD109-JLD256	18
4	GE14	GE14-P10DNAB408-16GZ-100T-145-T6-2554	100	JLD257-JLD392	18
5	GE14	GE14-P10DNAB406-18GZ-100T-145-T6-2809	48	JLN649-JLN696	19
7	GE14	GE14-P10DNAB396-18GZ-100T-145-T6-2808	192	JLN457-JLN648	19

Figure 1 – Dresden 3 Cycle 20 – Reference Loading Pattern

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60											2	19	2	1	1	1	1	2	19	2										
58										19	2	3	3	4	1	1	4	3	3	2	19									
56							19	2	19	1	3	2	3	2	1	1	2	3	2	3	1	19	2	19						
54						2	1	4	1	4	1	3	2	4	1	1	4	2	3	1	4	1	4	1	2					
52					2	2	2	3	4	3	3	1	3	3	3	3	3	3	1	3	3	4	3	2	2	2				
50				2	2	1	3	5	5	5	4	5	5	5	7	7	5	5	5	4	5	5	5	3	1	2	2			
48			19	1	2	3	3	7	7	7	7	7	7	7	4	4	7	7	7	7	7	7	7	3	3	2	1	19		
46			2	3	3	5	7	4	7	3	7	4	7	3	7	7	3	7	4	7	3	7	4	7	5	3	3	2		
44			19	1	4	5	7	7	4	7	4	7	4	7	4	4	7	4	7	4	7	4	7	7	5	4	1	19		
42		19	1	4	3	5	7	3	7	3	7	4	7	4	7	7	4	7	4	7	3	7	3	7	5	3	4	1	19	
40	2	2	3	1	3	4	7	7	4	7	3	7	4	7	3	3	7	4	7	3	7	4	7	7	4	3	1	3	2	2
38	19	3	2	3	1	5	7	4	7	4	7	3	7	4	7	7	4	7	3	7	4	7	4	7	5	1	3	2	3	19
36	2	3	3	2	3	5	7	7	4	7	4	7	3	7	4	4	7	3	7	4	7	4	7	7	5	3	2	3	3	2
34	1	4	2	4	3	5	7	3	7	4	7	4	7	4	7	7	4	7	4	7	4	7	3	7	5	3	4	2	4	1
32	1	1	1	1	3	7	4	7	4	7	3	7	4	7	3	3	7	4	7	3	7	4	7	4	7	3	1	1	1	1
30	1	1	1	1	3	7	4	7	4	7	3	7	4	7	3	3	7	4	7	3	7	4	7	4	7	3	1	1	1	1
28	1	4	2	4	3	5	7	3	7	4	7	4	7	4	7	7	4	7	4	7	4	7	3	7	5	3	4	2	4	1
26	2	3	3	2	3	5	7	7	4	7	4	7	3	7	4	4	7	3	7	4	7	4	7	7	5	3	2	3	3	2
24	19	3	2	3	1	5	7	4	7	4	7	3	7	4	7	7	4	7	3	7	4	7	4	7	5	1	3	2	3	19
22	2	2	3	1	3	4	7	7	4	7	3	7	4	7	3	3	7	4	7	3	7	4	7	7	4	3	1	3	2	2
20		19	1	4	3	5	7	3	7	3	7	4	7	4	7	7	4	7	4	7	3	7	3	7	5	3	4	1	19	
18			19	1	4	5	7	7	4	7	4	7	4	7	4	4	7	4	7	4	7	4	7	7	5	4	1	19		
16			2	3	3	5	7	4	7	3	7	4	7	3	7	7	3	7	4	7	3	7	4	7	5	3	3	2		
14			19	1	2	3	3	7	7	7	7	7	7	7	4	4	7	7	7	7	7	7	7	3	3	2	1	19		
12				2	2	1	3	5	5	5	4	5	5	5	7	7	5	5	5	4	5	5	5	3	1	2	2			
10					2	2	2	3	4	3	3	1	3	3	3	3	3	3	1	3	3	4	3	2	2	2				
8						2	1	4	1	4	1	3	2	4	1	1	4	2	3	1	4	1	4	1	2					
6							19	2	19	1	3	2	3	2	1	1	2	3	2	3	1	19	2	19						
4										19	2	3	3	4	1	1	4	3	3	2	19									
2											2	19	2	1	1	1	1	2	19	2										

Fuel Type	Bundle Name	# Assem	ID Range	Cycle First Loaded
19	SPC ATRIUM-9B 3.62 12Gd5.0/12Gd6.0/10Gd5.0	32	A3Y017-A3Y176	16
1	SPC ATRIUM-9B 3.78 11Gd5.0/11Gd6.0/10Gd7.0	84	A3Z001-A3Z112	17
2	SPC ATRIUM-9B 3.78 11Gd5.0/11Gd7.0/11Gd8.0/10Gd8.0	84	A3Z113-A3Z240	17
3	GE14-P10DNAB411-4G7.0/9G6.0-100T-145-T6-2553	148	JLD109-JLD256	18
4	GE14-P10DNAB408-16GZ-100T-145-T6-2554	136	JLD257-JLD392	18
5	GE14-P10DNAB406-18GZ-100T-145-T6-2809	48	JLN649-JLN696	19
7	GE14-P10DNAB396-18GZ-100T-145-T6-2808	192	JLN457-JLN648	19

Figure 2 Dresden 3 Cycle 19 – Reference Loading Pattern

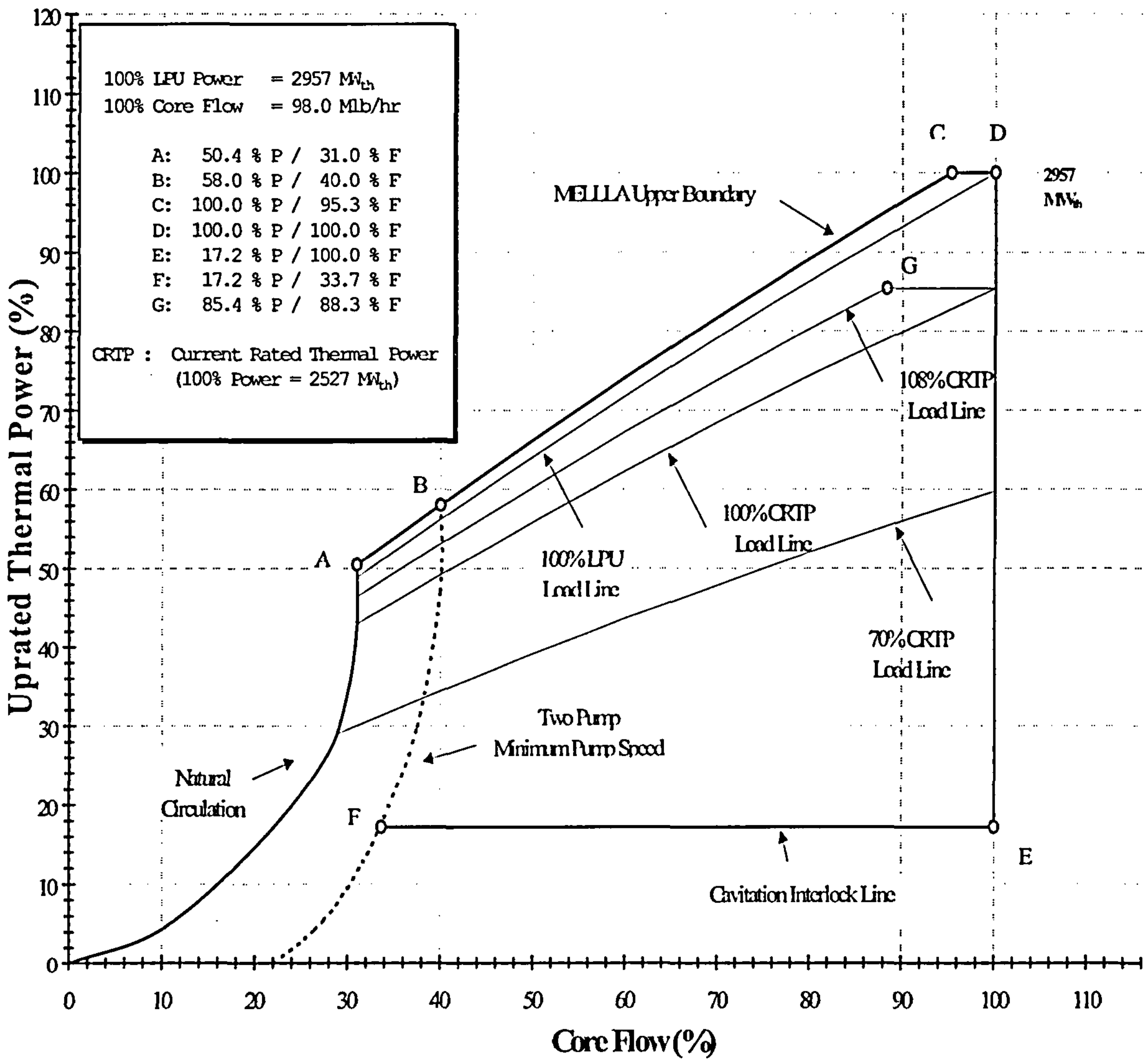

Figure 3 – DNPS Power Flow Map (Nominal Feedwater Temperature)

a,c

[ ]

Figure 4 Dresden 3 Cycle 20 SLMCPR Results for SVEA-96 Optima2 Fuel

Figure 5 – Assembly Histograms

a,c

Figure 6 – Assembly Histograms

a,c

Figure 7 – Assembly Histograms

a,c

Figure 8 – Assembly Histograms

a,c

Figure 9 – Assembly Histograms

a,c

Figure 10 – Assembly Histograms

a,c

Figure 11 – Assembly Histograms

a,c

Figure 12 – Assembly Histograms

a,c

Figure 13 – Assembly Histograms

a,c

Figure 14 – Assembly Histograms

a,c

Figure 15 – Assembly Histograms

a,c

Figure 16 – Assembly Histograms

a,c

Figure 17 – Assembly Histograms

a,c

Figure 18 – Assembly Histograms

a,c

Figure 19 – Assembly Histograms

a,c

Figure 20 – Assembly Histograms

a,c

Figure 21 – Assembly Histograms

a,c

Figure 22 – Assembly Histograms

a,c

Figure 23 – Assembly Histograms

a,c

Figure 24 – Assembly Histograms

a,c

Figure 25 – Assembly Histograms

a,c