

ATTACHMENT 23

**Browns Ferry Nuclear Plant (BFN)
Unit 1**

Technical Specifications (TS) Change 467

**Revision of Technical Specifications to allow utilization of AREVA NP
fuel and associated analysis methodologies**

Safety Limit Minimum Critical Power Ratio

Attached is the non-proprietary version of safety limit MCPR analyses results supporting 120% OLTP operation.



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AREVA NP Inc.,
an AREVA and Siemens company

Engineering Information Record

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**Browns Ferry Unit 1 Cycle 9
MCPR Safety Limit Analysis
(120% OLTP)**

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

Safety related? ☒ YES ☐ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Does this document contain Customer Required Format? ☐ YES ☒ NO

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Revision No.	Date	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	9/3/09		Initial issue. This is the nonproprietary version of 51-9119738-000.

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

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Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

1.0 Summary and Results

This report presents the Browns Ferry Unit 1 Cycle 9 (BFE1-9) MCPR safety limit analysis results for 120% original licensed thermal power (OLTP) conditions. The MCPR safety limit analysis results presented are applicable in all the equipment out-of-service scenarios and extended operating domains identified in Reference 1.

The MCPR safety limit results presented support 1.07 for two-loop operation (TLO) and 1.10 for single-loop operation (SLO). Therefore, updates to the Browns Ferry Unit 1 Technical Specifications would be required for the BFE1-9 120% OLTP MCPR safety limit.

Reactor system measurement uncertainties are statistically convolved with MCPR calculational uncertainties to determine a MCPR safety limit that ensures that at least 99.9% of the fuel rods in the reactor core would not be expected to experience boiling transition during normal operation or an anticipated operational occurrence. [

] The MCPR safety limit is used in conjunction with transient analysis results to establish the MCPR operating limit. The MCPR safety limit methodology is described in Reference 2.

The final 120% OLTP core design and step-through, developed by AREVA NP* to meet the operating requirements specified by TVA, was used in the BFE1-9 120% OLTP MCPR safety limit analysis. The BFE1-9 120% OLTP design supports licensed rated power of 3,952 MWt and operation to licensing end of cycle (EOC) cycle exposure of approximately 19,635 MWd/MTU. The design includes extensions for final feedwater temperature reduction (FFTR) and coastdown.

The BFE1-9 120% OLTP MCPR safety limit analysis used the SPCB critical power correlation additive constants and additive constant uncertainty reported in Reference 3[†] for ATRIUM™-10[‡] fuel. [

] The impacts of channel bow were explicitly accounted for in the analysis consistent with the process described in Reference 2. The local power peaking uncertainty is based upon the monitoring computer code as reported in Reference 4. The relationship between assembly flow rate and assembly power was determined for each fuel type using the methodology and assembly flow rate uncertainty reported in Reference 2.

* AREVA NP Inc. is an AREVA and Siemens company

† AREVA has submitted an addendum to the NRC for Reference 3. It is Addendum 1 Revision 0 titled, *SPCB Additive Constants for ATRIUM-10 Fuel*. It addresses Condition Report 2007-3653 regarding the CPR test loop power error. Analyses for BFE1-9 120% OLTP incorporate this addendum.

‡ ATRIUM is a trademark of AREVA NP.

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

The analysis supports:

- Fuel- and plant-related uncertainties for BFE1-9 120% OLTP presented in Table 1.
- 50% of the LPRMs out of service (LPRM bypass model on or off).
- Up to 2 TIP machines out of service, or the equivalent number of TIP channels.
- 2500 EFPH LPRM calibration interval.
- No reused channels.

[

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Table 2 presents a summary of the analysis results including the MCPR safety limit and the percentage of rods expected to experience boiling transition for both TLO and SLO. Analyses were performed using the power distributions from each exposure in the design step-through. The safety limit radial power histograms for the limiting TLO and SLO cycle exposures of [

], respectively (i.e., the exposures that results in the highest number of rods expected to experience boiling transition) are presented in Figures 1 and 2. The BFE1-9 120% OLTP core loading and fuel design are presented in Table 3 and Figures 3 through 7.

References

1. 51-9107387-000, "Browns Ferry Unit 1 Cycle 9 Calculation Plan," AREVA NP, May 2009.
2. ANF-524(P)(A) Revision 2 and Supplements 1 and 2, *ANF Critical Power Methodology for Boiling Water Reactors*, Advanced Nuclear Fuels Corporation, November 1990.
3. EMF-2209(P)(A) Revision 2, *SPCB Critical Power Correlation*, Framatome ANP, September 2003.
4. EMF-2158(P)(A) Revision 0, *Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2*, Siemens Power Corporation, October 1999.
5. Letter, H. Donald Curet (AREVA) to H.J. Richings (USNRC), "POWERPLEX® Core Monitoring: Failed or Bypassed Instrumentation and Extended Calibration," HDC:96:012, May 6, 1996. (38-9043714-000).
6. EMF-2245(P)(A) Revision 0, *Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel*, Siemens Power Corporation, August 2000.

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

Table 1 Fuel- and Plant-Related Uncertainties MCPR Safety Limit Analyses	
Parameter	Standard Deviation
<i>Fuel-Related Uncertainties</i>	
[	
]	
<i>Plant-Related Uncertainties</i>	
Feedwater flow rate	1.8%
Feedwater temperature	0.8%
Core pressure	0.7%
Total core flow rate	
TLO	2.5%
SLO	6.0%

* []

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

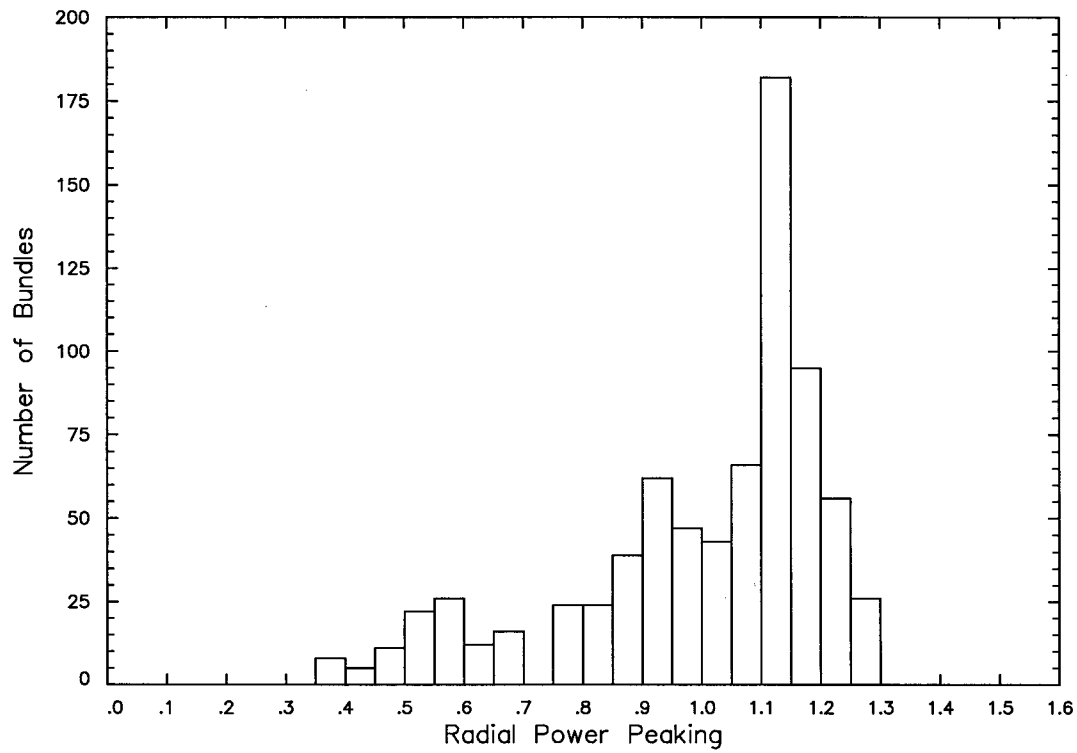
**Table 2 Results Summary
for MCPR Safety Limit Analysis**

SLMCPR	Percentage of Rods in Boiling Transition
TLO – 1.07	0.0687
SLO – 1.10	0.0731

Table 3 Core Loading

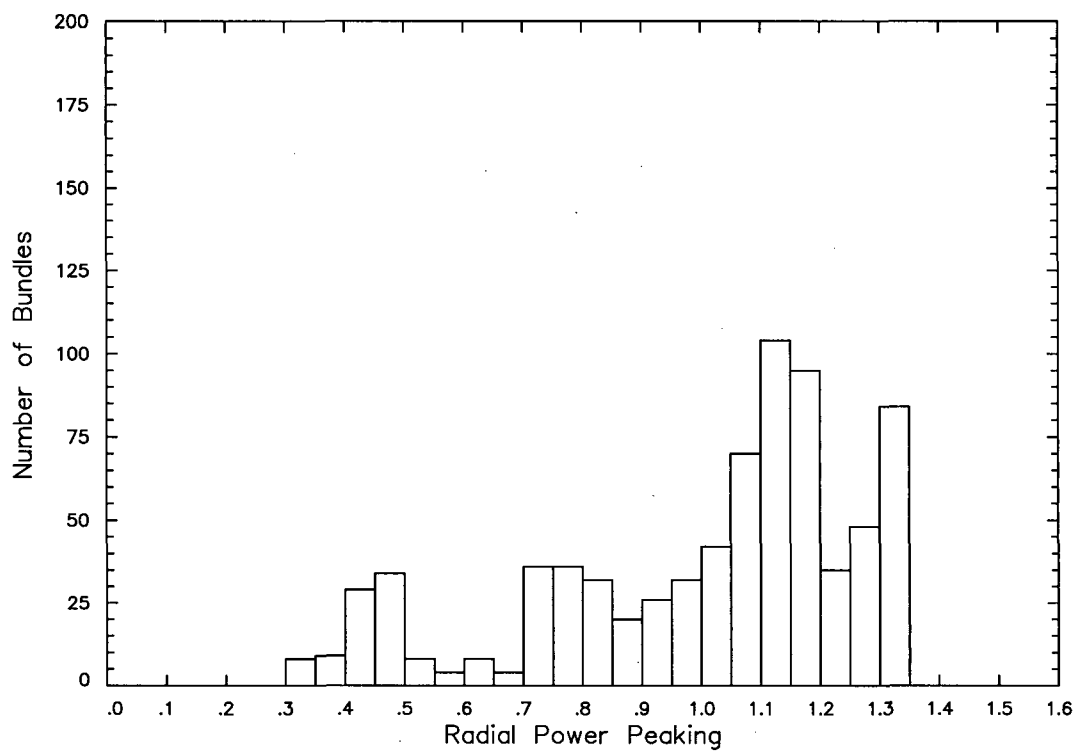
Fuel Description	Cycle Loaded	Nuclear Fuel Type	Total Number of Assemblies	Serial Number Prefix
GE14	7	4	24	JLX
GE14	7	5	12	JLX
GE14	7	6	17	JLX
GE14	7	9	32	JLX
GE14	7	10	12	JLX
GE14	7	11	8	JLX
GE14	8	14	48	JYE
GE14	8	15	96	JYE
GE14	8	16	64	JYE
GE14	8	17	48	JYE
GE14	8	18	71	JYE
ATRIUM-10	9	19	192	FAA
ATRIUM-10	9	20	40	FAA
ATRIUM-10	9	21	100	FAA

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)



**Figure 1 Radial Power Distribution for
TLO Limiting Exposure of []**

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)



**Figure 2 Radial Power Distribution for
SLO Limiting Exposure of []**

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
60									JLX621	JLX623	JLX533	JLX643	JYE381	JLX675	JLX725
58								JLX625	JYE169	JYE365	JYE245	JYE325	JYE317	JYE333	JYE309
56						JLX627	JLX478	JYE213	FAA209	FAA233	FAA253	FAA322	FAA177	FAA314	JYE261
54						JLX530	JYE145	JYE341	FAA277	JYE421	FAA117	JYE273	FAA289	JYE133	FAA261
52					JYE369	JYE189	FAA273	FAA265	JYE373	FAA305	FAA197	FAA185	JYE293	FAA221	JYE285
50			JLX616	JLX541	JYE185	JYE113	FAA001	JYE389	FAA241	JYE409	FAA169	JYE117	FAA201	JYE413	FAA225
48			JLX477	JYE141	FAA281	FAA065	FAA329	FAA013	JYE349	FAA129	JYE277	FAA045	JYE125	FAA141	JYE101
46		JLX615	JYE197	JYE345	FAA269	JYE393	FAA093	JYE221	FAA125	JYE301	FAA109	JYE253	FAA157	JYE157	FAA097
44	JLX613	JYE177	FAA213	FAA293	JYE377	FAA245	JYE353	FAA121	JYE397	FAA149	JYE241	FAA029	JYE229	FAA041	JYE153
42	JLX614	JYE361	FAA237	JYE425	FAA307	JYE405	FAA137	JYE305	FAA133	JYE401	FAA085	JYE149	FAA021	JLX350	FAA069
40	JLX543	JYE249	FAA249	FAA165	FAA193	FAA173	JYE281	FAA161	JYE201	FAA053	JYE357	FAA077	JYE165	FAA005	JLX291
38	JLX666	JYE329	FAA321	JYE269	FAA189	JYE121	FAA113	JYE257	FAA025	JYE217	FAA073	JYE109	FAA105	JYE181	FAA081
36	JLX448	JYE321	FAA181	FAA285	JYE297	FAA205	JYE129	FAA153	JYE233	FAA057	JYE237	FAA101	JLX280	FAA297	JYE209
34	JLX659	JYE337	FAA313	JYE137	FAA217	JYE417	FAA145	JYE173	FAA049	JLX275	FAA009	JYE225	FAA301	JLX365	FAA061
32	JLX717	JYE313	JYE265	FAA257	JYE289	FAA229	JYE105	FAA089	JYE161	FAA017	JLX362	FAA037	JYE205	FAA033	JYE193
30	JLX718	JYE316	JYE268	FAA264	JYE292	FAA228	JYE108	FAA100	JYE164	FAA072	JLX276	FAA084	JYE212	FAA064	JYE192
28	JLX663	JYE340	FAA320	JYE140	FAA224	JYE420	FAA144	JYE176	FAA044	JLX361	FAA008	JYE188	FAA300	JLX321	FAA036
26	JYE388	JYE324	FAA180	FAA292	JYE300	FAA204	JYE132	FAA160	JYE236	FAA024	JYE156	FAA108	JLX299	FAA304	JYE208
24	JLX544	JYE332	FAA328	JYE272	FAA188	JYE124	FAA048	JYE260	FAA032	JYE220	FAA080	JYE116	FAA104	JYE224	FAA040
22	JLX536	JYE252	FAA256	FAA120	FAA200	FAA172	JYE284	FAA016	JYE240	FAA088	JYE364	FAA076	JYE244	FAA012	JLX279
20	JLX619	JYE360	FAA236	JYE428	FAA308	JYE408	FAA132	JYE308	FAA152	JYE400	FAA056	JYE216	FAA060	JLX366	FAA020
18	JLX620	JYE180	FAA212	FAA280	JYE380	FAA244	JYE356	FAA128	JYE404	FAA136	JYE200	FAA028	JYE232	FAA052	JYE160
16		JLX618	JYE152	JYE348	FAA268	JYE396	FAA112	JYE228	FAA124	JYE304	FAA164	JYE256	FAA156	JYE204	FAA092
14			JLX447	JYE144	FAA276	FAA004	FAA332	FAA096	JYE352	FAA140	JYE280	FAA116	JYE128	FAA148	JYE104
12			JLX617	JLX542	JYE196	JYE112	FAA068	JYE392	FAA248	JYE412	FAA176	JYE120	FAA208	JYE416	FAA232
10					JYE372	JYE184	FAA284	FAA272	JYE376	FAA309	FAA196	FAA192	JYE296	FAA220	JYE288
8						JLX469	JYE148	JYE344	FAA296	JYE424	FAA168	JYE276	FAA288	JYE136	FAA260
6						JLX628	JLX479	JYE168	FAA216	FAA240	FAA252	FAA327	FAA184	FAA319	JYE264
4								JLX626	JYE172	JYE368	JYE248	JYE328	JYE320	JYE336	JYE312
2									JLX622	JLX624	JLX531	JLX673	JYE384	JLX670	JLX728

Figure 3 Reference Loading Pattern

	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60	JLX729	JLX691	JYE382	JLX688	JLX558	JLX633	JLX635								
58	JYE310	JYE334	JYE318	JYE326	JYE246	JYE366	JYE170	JLX631							
56	JYE274	FAA315	FAA182	FAA323	FAA250	FAA238	FAA214	JYE202	JLX482	JLX629					
54	FAA258	JYE134	FAA286	JYE270	FAA166	JYE422	FAA294	JYE342	JYE146	JLX491					
52	JYE286	FAA218	JYE294	FAA190	FAA194	FAA306	JYE374	FAA270	FAA282	JYE182	JYE370				
50	FAA230	JYE414	FAA206	JYE118	FAA174	JYE410	FAA246	JYE390	FAA066	JYE110	JYE194	JLX547	JLX640		
48	JYE102	FAA146	JYE126	FAA114	JYE282	FAA138	JYE350	FAA094	FAA330	FAA002	FAA274	JYE142	JLX481		
46	FAA090	JYE166	FAA154	JYE254	FAA162	JYE302	FAA122	JYE226	FAA110	JYE394	FAA266	JYE346	JYE150	JLX639	
44	JYE158	FAA050	JYE230	FAA026	JYE198	FAA134	JYE402	FAA126	JYE354	FAA242	JYE378	FAA278	FAA210	JYE178	JLX637
42	FAA018	JLX355	FAA058	JYE214	FAA054	JYE398	FAA150	JYE306	FAA130	JYE406	FAA312	JYE426	FAA234	JYE358	JLX638
40	JLX286	FAA010	JYE242	FAA074	JYE362	FAA086	JYE238	FAA014	JYE278	FAA170	FAA198	FAA118	FAA254	JYE250	JLX553
38	FAA038	JYE222	FAA102	JYE114	FAA078	JYE218	FAA030	JYE258	FAA046	JYE122	FAA186	JYE262	FAA324	JYE330	JLX545
36	JYE210	FAA302	JLX330	FAA106	JYE154	FAA022	JYE234	FAA158	JYE130	FAA202	JYE298	FAA290	FAA178	JYE322	JYE386
34	FAA034	JLX229	FAA298	JYE186	FAA006	JLX412	FAA042	JYE174	FAA142	JYE418	FAA222	JYE138	FAA316	JYE338	JLX692
32	JYE190	FAA062	JYE206	FAA082	JLX403	FAA070	JYE162	FAA098	JYE106	FAA226	JYE290	FAA262	JYE266	JYE314	JLX739
30	JYE195	FAA035	JYE207	FAA039	JLX290	FAA019	JYE163	FAA091	JYE107	FAA231	JYE291	FAA259	JYE263	JYE315	JLX740
28	FAA063	JLX287	FAA303	JYE227	FAA011	JLX343	FAA051	JYE175	FAA147	JYE419	FAA219	JYE139	FAA317	JYE339	JLX702
26	JYE211	FAA299	JLX311	FAA103	JYE239	FAA059	JYE235	FAA155	JYE131	FAA207	JYE299	FAA287	FAA183	JYE323	JYE387
24	FAA083	JYE183	FAA107	JYE111	FAA075	JYE219	FAA027	JYE259	FAA115	JYE123	FAA191	JYE271	FAA325	JYE331	JLX701
22	JLX354	FAA007	JYE151	FAA079	JYE359	FAA055	JYE203	FAA163	JYE283	FAA175	FAA195	FAA167	FAA251	JYE251	JLX548
20	FAA071	JLX351	FAA023	JYE215	FAA087	JYE403	FAA135	JYE307	FAA139	JYE407	FAA311	JYE427	FAA239	JYE363	JLX492
18	JYE155	FAA043	JYE231	FAA031	JYE243	FAA151	JYE399	FAA123	JYE355	FAA247	JYE379	FAA295	FAA215	JYE179	JLX644
16	FAA099	JYE159	FAA159	JYE255	FAA015	JYE303	FAA127	JYE223	FAA095	JYE395	FAA271	JYE347	JYE199	JLX642	
14	JYE103	FAA143	JYE127	FAA047	JYE279	FAA131	JYE351	FAA111	FAA331	FAA067	FAA283	JYE143	JLX515		
12	FAA227	JYE415	FAA203	JYE119	FAA171	JYE411	FAA243	JYE391	FAA003	JYE115	JYE187	JLX560	JLX641		
10	JYE287	FAA223	JYE295	FAA187	FAA199	FAA310	JYE375	FAA267	FAA275	JYE191	JYE371				
8	FAA263	JYE135	FAA291	JYE275	FAA119	JYE423	FAA279	JYE343	JYE147	JLX559					
6	JYE267	FAA318	FAA179	FAA326	FAA255	FAA235	FAA211	JYE167	JLX483	JLX630					
4	JYE311	JYE335	JYE319	JYE327	JYE247	JYE367	JYE171	JLX632							
2	JLX732	JLX689	JYE383	JLX546	JLX556	JLX634	JLX636								

Figure 3 Reference Loading Pattern (Continued)

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

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Fuel Type	Description	Cycle Loaded	No. Per Quarter core
4	GE14-P10DNAB157-NOG	7	6
5	GE14-P10DNAB377-16GZ	7	3
6	GE14-P10DNAB402-16GZ	7	5
9	GE14-P10DNAB419-16GZ	7	7
10	GE14-P10DNAB368-15GZ	7	3
11	GE14-P10DNAB402-19GZ	7	2
14	GE14-P10DNAB406-16GZ	8	12
15	GE14-P10DNAB400-17GZ	8	24
16	GE14-P10DNAB406-15GZ	8	16
17	GE14-P10DNAB417-16GZ	8	12
18	GE14-P10DNAB418-16GZ	8	18
19	A10-3761B-14GV80-FAA	9	48
20	A10-3831B-12GV80-FAA	9	10
21	A10-4171B-14GV80-FAA	9	25

**Figure 4 Lower Right Quarter Core Layout
By Fuel Type**

Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

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Browns Ferry Unit 1 Cycle 9 MCPR Safety Limit Analysis (120% OLTP)

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