COOPER NUCLEAR STATION

CORE OPERATING LIMITS REPORT

Non-Proprietary Version

Cycle 23
Revision 0

	Print	Sign	Date
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INTRODUCTION

The Core Operating Limits Report (COLR) provides the limits for operation of the Cooper Nuclear Station for Cycle 23. Cooper Nuclear Station Technical Specification 5.6.5(a) requires the COLR to contain the following limits:

- The Average Planar Linear Heat Generation Rates for Specification 3.2.1
- The Minimum Critical Power Ratio for Specifications 3.2.2 and 3.7.7
- The three Rod Block Monitor Upscale Allowable Values for Specification 3.3.2.1
- The power/flow map defining the Stability Exclusion Region for Specification 3.4.1.

In addition, the following information is required to be in the COLR:

- Turbine Bypass System response time for Surveillance Requirement 3.7.7.3
- Maximum allowable Linear Heat Generation Rate for Technical Resource Manual Specification T3.2.1.

The analytical methods used to determine the core operating limits are those previously reviewed and approved by the NRC as required by Technical Specification 5.6.5(b). These methods are:

- NEDE-24011-P-A-14, "General Electric Standard Application for Reactor Fuel", June 2000.
- NEDE-23785-1-P-A, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident", Volume III, Revision 1, October 1984.
- NEDO-31960-A and NEDO-31960-A Supplement 1, "BWR Owner's Group Long-Term Stability Solutions Licensing Methodology", November 1995.

The core operating limits have been determined such that all applicable limits of the safety analysis are met as required by Technical Specifications 5.6.5(c).

AVERAGE PLANAR LINEAR HEAT GENERATION RATES

Two recirculation loop operation

The APLHGR limit is calculated by determining the maximum APLHGR limit from Attachments 1-6. The limits in Attachments 1-6 are a function of average planar exposure and are specified for each fuel type.

The APLHGR limit is adjusted for off-rated power and flow conditions by determining the following:

MAPLHGR(f) = MAPFAC(f) * APLHGR limit

MAPLHGR(p) = MAPFAC(p) * APLHGR limit

Where f is the core flow in percent of rated and p is the core power in percent of rated. The values for MAPFAC(f) and MAPFAC(p) are determined from Attachments 13 and 14, respectively.

The Technical Specification limit is determined as follows:

APLHGR TS Limit = Maximum(MAPLHGR(f), MAPLHGR(p))

The maximum APLHGR values were obtained from Reference 1. The MAPFAC(f) and MAPFAC(p) values are found in Reference 2.

Single recirculation loop operation

The Technical Specification limit is determined as follows:

APLHGR TS Limit = Two recirculation loop operation APLHGR limit * 0.91.

The single loop operation multiplier is specified in Reference 1.

MINIMUM CRITICAL POWER RATIO

Two recirculation loop operation

The Technical Specification limit is determined as follows:

MCPR TS Limit = Minimum(OLMCPR(p), OLCMPR(f))

OLMCPR(p) is the operating limit MCPR as a function of core thermal power. It is determined as follows:

For 25% ≤ P < 30%, OLMCPR(p) is found directly on Attachment 15.

For P≥30%, OLMCPR(p) is determined by calculating the following:

OLMCPR(p) = K(p)*OLMCPR(τ)

Where K(p) is determined by using Attachment 15.

OLMCPR(τ) is determined directly by using Attachments 17-19. For each scram time test τ is calculated using the following method from Reference 5:

The mean scram time (Tave) for insertion to notch 36 is obtained as follows:

$$Tave = \frac{\sum_{i=1}^{n} Ni * Ti}{\sum_{i=1}^{n} Ni}$$

where i is the scram time test sequential identification number, n is the number of scram time tests performed to date in the cycle (including beginning of cycle), Ti is the average insertion time to notch 36 for test I, and Ni is the number of control rods tested in test i.

The 20% insertion conformance limit scram time (T_B) is obtained as follows:

$$T_B = 0.830 + 0.367 * \left[\frac{1}{\sum_{i=1}^{n} Ni} \right]^{1/2}$$

where i, n, and Ni are defined as for Tave.

The scram time quality factor (τ) is then calculated as follows:

If Tave ≤ T_B, then τ = 0. If Tave > T_B , then $\tau = \left[\frac{Tave - T_B}{T_A - T_B} \right]$. T_A is the Technical Specification limit for 20% insertion (to notch 36) and is equal to 1.08 seconds.

OLMCPR(τ) is determined by using Attachment 17 when core exposure is beginning of cycle to middle of cycle. OLMCPR(τ) is determined using Attachment 18 when core exposure is middle of cycle to end of cycle. Middle of cycle is defined as end of rated power (all rods out, rated power, rated flow) minus 2480 MWD/MTU. OLMCPR(τ) is determined using Attachment 19 when one turbine bypass valve is out of service, regardless of core exposure.

OLMCPR(f) is the operating limit MCPR as a function of core flow. It is found directly on Attachment 16.

The information for Attachments 15,17,18, and 19 were obtained from Reference 1. The information for Attachment 16 is from Reference 7.

Single recirculation loop operation

The OLMCPR for single loop operation is the OLMCPR value for two recirculation loop operation plus 0.02. The 0.02 adder is obtained from Reference 8.

Use of Full Arc Turbine Control Valve

When using full arc turbine control valve mode (CNS operating procedures refer to this as single valve mode), the OLMCPR value is the OLMCPR for two recirculation loop or single recirculation loop operation as determined above plus 0.03. The 0.03 adder is obtained from Reference 1.

ROD BLOCK MONITOR UPSCALE ALLOWABLE VALUES

The Rod Block Monitor (RBM) upscale (power referenced) allowable values were determined in Reference 6. The allowable values are as follows:

Lowest Rated MCPR Limit	Low Trip Set Point (LTSP) (LPSP≤P≤IPSP)	Intermediate Trip Set Point (ITSP) IPSP<P≤HPSP	High Trip Set Point (HTSP) HPSP<P
≥1.31	≤117.0/125	≤112.5/125	≤107.5/125

LPSP, IPSP, and HPSP are the Low Power Set Point, Intermediate Power Set Point, and High Power Set Point, respectively.

The trip level settings associated with this MCPR limit have been verified to bound the Rod Withdrawal Error Analysis for Cycle 23 operation as found in Reference 1.

TURBINE BYPASS SYSTEM RESPONSE TIME

The system response time for the Turbine Bypass System to be at 80% of rated bypass flow is 0.3 seconds. This was obtained from Reference 3.

MAXIMUM ALLOWABLE LINEAR HEAT GENERATION RATE

Two recirculation loop operation

The LHGR limit is calculated by determining the maximum LHGR limit from Attachments 7-12. The limits in Attachments 7-12 are a function of peak pellet exposure and pin type. The bounding limits are specified for each fuel type.

The LHGR limit is adjusted for off-rated power and flow conditions by determining the following:

LHGR(f) = MAPFAC(f) * LHGR limit

LHGR(p) = MAPFAC(p) * LHGR limit

Where f is the core flow in percent of rated and p is the core power in percent of rated. The values for MAPFAC(f) and MAPFAC(p) are determined from Attachments 13 and 14, respectively.

The Technical Specification limit is determined as follows:
LHGR TS Limit = Maximum(LHGR(f), LHGR(p))

The maximum LHGR values were obtained from Reference 4. The MAPFAC(f) and MAPFAC(p) values are found in Reference 2. MAPFAC(f) and MAPFAC(p) are applied to LHGR off-rated limits as directed in Reference 1.

Single recirculation loop operation

The Technical Specification limit is determined as follows:

LHGR TS Limit = Two recirculation loop LHGR limit * 0.91.

The single loop operation multiplier is specified in Reference 1.

POWER/FLOW MAP

The power/flow map defining the Stability Exclusion Region is in Figure 20. The information on the Stability Exclusion Region was obtained from Reference 1.

REFERENCES

1) 0000-0025-0510-SRLR, "Supplemental Reload Licensing Report for Cooper Nuclear Station Reload 22 Cycle 23", Revision 0, November 2004.
2) GE-NE-L12-00867-12, "Project Task Report Cooper Nuclear Station MIG Project Task 900: Transient Analysis", Revision 1, May 2000.
3) GE Design Specification 22A2859, "Turbine-Generator and Steam Bypass System", Paragraph 4.3.8, Revision 3.
4) 0000-0025-0510-FBIR, "Fuel Bundle Information Report for Cooper Nuclear Station Reload 22 Cycle 23", Revision 0, November 2004.
5) CNS Procedure 10.9, "Control Rod Scram Time Evaluation".
6) NEDC 98-024, "APRM - RBM Setpoint Calculation", latest revision.
7) GE-NE-0000-0033-3261-R1, "Stability SRLR Insert for Cooper Cycle 23", January 15, 2005.
8) FRL-NPP-HP1-05-003, "Cooper Cycle 23 Revised SLMCPR", February 3, 2005.

Attachment 1 – MAPLHGR Limits for Bundle Type GE14-P10HNAB385-14GZ-100T-148-T6-3881 (GE14B)

Average Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	9.17
0.22	9.24
1.10	9.38
2.20	9.59
3.31	9.82
4.41	9.95
5.51	10.08
6.61	10.19
7.72	10.27
8.82	10.35
9.92	10.42
11.02	10.50
12.13	10.58
13.23	10.68
14.33	10.78
15.43	10.87
16.53	10.83
18.74	10.71
22.05	10.48
27.56	10.06
32.22	9.70
33.07	9.63
38.58	9.17
44.09	8.67
49.60	8.08
55.12	7.45
60.63	6.81
62.65	6.56
62.71	6.56
63.72	6.62
63.83	6.65

Attachment 2 – MAPLHGR Limits for Bundle Type GE14-P10HNAB379-17GZ-100T-150-T6-2476 (GE14C)

Average Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	9.29
0.22	9.35
1.10	9.47
2.20	9.64
3.31	9.83
4.41	10.02
5.51	10.22
6.61	10.42
7.72	10.55
8.82	10.66
9.92	10.78
11.02	10.89
12.13	10.99
13.23	11.07
14.33	11.11
15.43	11.15
16.53	11.06
18.74	10.86
22.05	10.57
27.56	10.11
33.07	9.67
33.42	9.64
38.58	9.24
44.09	8.79
49.60	8.25
55.12	7.69
60.63	5.49
61.94	4.89
62.26	4.92
62.69	4.82
62.75	4.82

Attachment 3 – MAPLHGR Limits for Bundle Type GE14-P10DNAB393-17GZ-100T-150-T6-2611 (GE14C)

Average Planar Exposure (GWd/MT)	MAPLHGR (kW/ft)
0.00	9.42
0.22	9.50
1.10	9.64
2.20	9.84
3.31	10.05
4.41	10.27
5.51	10.47
6.61	10.64
7.72	10.77
8.82	10.91
9.92	11.04
11.02	11.16
12.13	11.26
13.23	11.35
14.33	11.42
15.43	11.42
16.53	11.42
18.74	11.26
22.05	10.95
27.56	10.41
33.07	9.89
33.42	9.86
38.58	9.38
44.09	8.87
49.60	8.35
55.12	7.78
60.63	5.87
62.92	4.83
62.95	4.82
63.32	4.88
63.35	4.86

Attachment 4 – MAPLHGR Limits for Bundle Type GE14-P10DNAB398-16GZ-100T-150-T6-2569 (GE14C)

Average Planar Exposure (GWd/MT)	MAPLHGR (kW/ft)
0.00	9.60
0.22	9.61
1.10	9.68
2.20	9.83
3.31	10.01
4.41	10.21
5.51	10.43
6.61	10.63
7.72	10.84
8.82	11.05
9.92	11.24
11.02	11.32
12.13	11.40
13.23	11.42
14.33	11.42
15.43	11.42
16.53	11.42
18.74	11.36
22.05	11.02
27.56	10.45
33.07	9.90
33.42	9.87
38.58	9.40
44.09	8.90
49.60	8.38
55.12	7.81
60.63	6.07
63.37	4.82
63.39	4.82
63.50	5.24
64.29	4.89
64.32	4.88

Attachment 5 – MAPLHGR Limits for Bundle Type GE14-P10DNAB395-14GZ-100T-150-T6-2800 (GE14C)

Average Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	9.31
0.22	9.40
1.10	9.55
2.20	9.72
3.31	9.90
4.41	10.08
5.51	10.23
6.61	10.37
7.72	10.51
8.82	10.65
9.92	10.79
11.02	10.94
12.13	11.08
13.23	11.21
14.33	11.33
15.43	11.42
16.53	11.42
18.74	11.33
22.05	11.13
27.56	10.66
33.07	10.11
33.42	10.07
38.58	9.57
44.09	9.04
49.60	8.50
55.12	7.95
60.63	6.43
63.50	5.13
64.16	4.83
64.20	4.84
64.82	4.88
64.86	4.87

Attachment 6 – MAPLHGR Limits for Bundle Type GE14-P10DNAB393-17GZ-100T-150-T6-2801 (GE14C)

Average Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	8.89
0.22	8.99
1.10	9.15
2.20	9.36
3.31	9.58
4.41	9.77
5.51	9.97
6.61	10.13
7.72	10.28
8.82	10.43
9.92	10.58
11.02	10.73
12.13	10.89
13.23	11.04
14.33	11.18
15.43	11.30
16.53	11.29
18.74	11.25
22.05	11.10
27.56	10.63
33.07	10.08
33.42	10.05
38.58	9.55
44.09	9.02
49.60	8.47
55.12	7.91
60.63	6.35
63.50	5.04
63.97	4.83
64.00	4.83
64.57	4.87
64.62	4.86

Attachment 7 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10HNAB385-14GZ-100T-148-T6-3881 (GE14B) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

{3}]]

Attachment 8 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10HNAB379-17GZ-100T-150-T6-2476 (GE14C) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

(3)]]

Attachment 9 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10DNAB393-17GZ-100T-150-T6-2611 (GE14C) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

{3}]]

Attachment 10 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10DNAB398-16GZ-100T-150-T6-2569 (GE14C) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

{3}]]

Attachment 11 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10DNAB395-14GZ-100T-150-T6-2800 (GE14C) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

{3}]]

Attachment 12 – UO_2/Gd Thermal-Mechanical LHGR Limits for Bundle Type GE14-P10DNAB393-17GZ-100T-150-T6-2801 (GE14C) {Proprietary}

Peak Pellet Exposure	UO_2 LHGR Limit
GWd/MT	kW/ft
0.00	13.40

[[

(3)]]

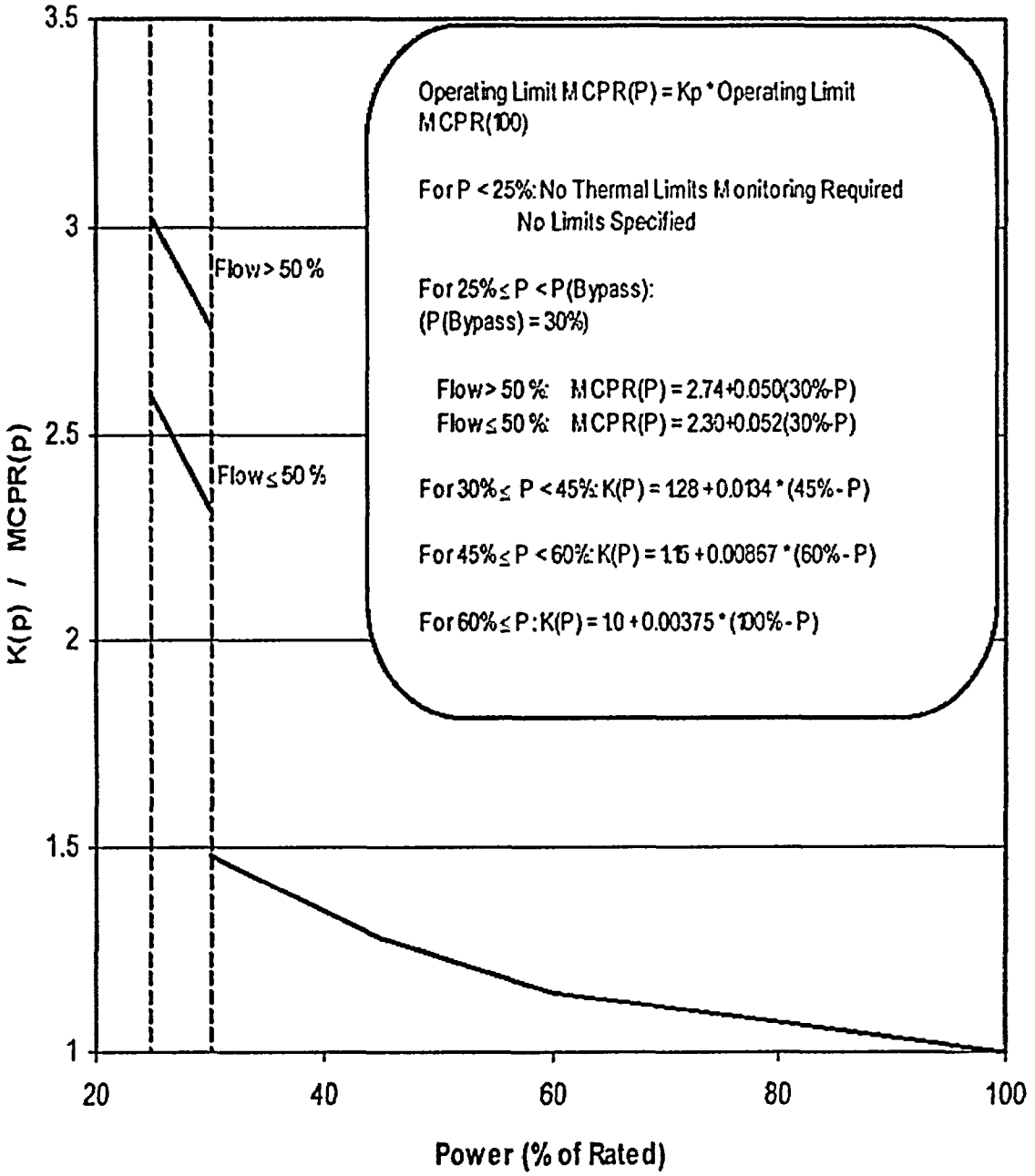
Attachment 13 - Flow Dependent MAPLHGR Factor MAPFAC(f) (also used for LHGR)
{Proprietary}
[[

(3)]]

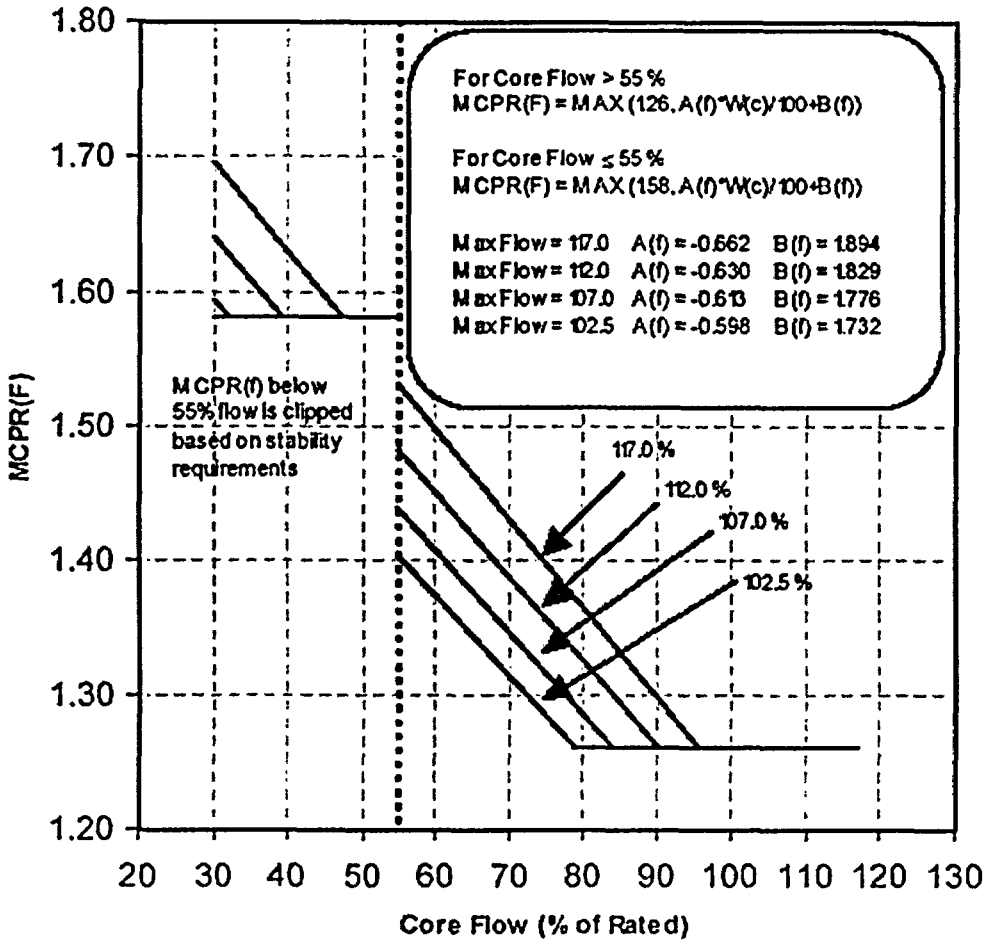
Attachment 14 - Power Dependent MAPLHGR Factor MAPFAC(p) (also used for LHGR)
{Proprietary}
[[

{3}]]

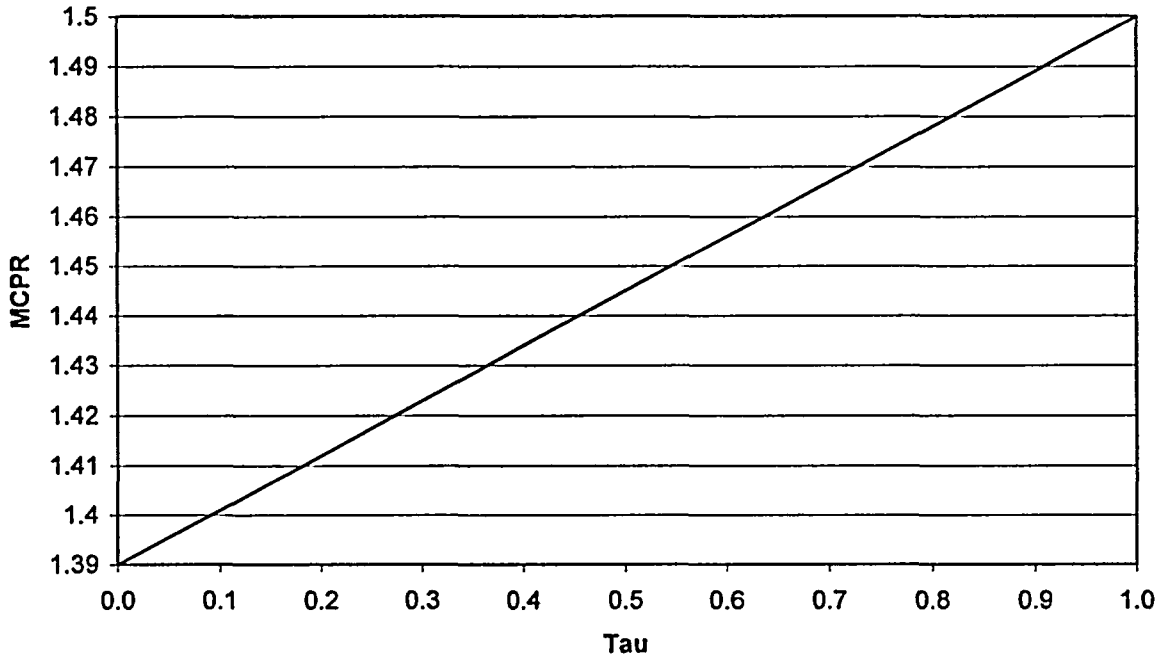
Attachment 15 - Power-Dependent K(p) and OLMCPR for GE14 with Safety Limit = 1.12



Attachment 16 - Flow Dependent MCPR for GE14 Fuel with Safety Limit = 1.12

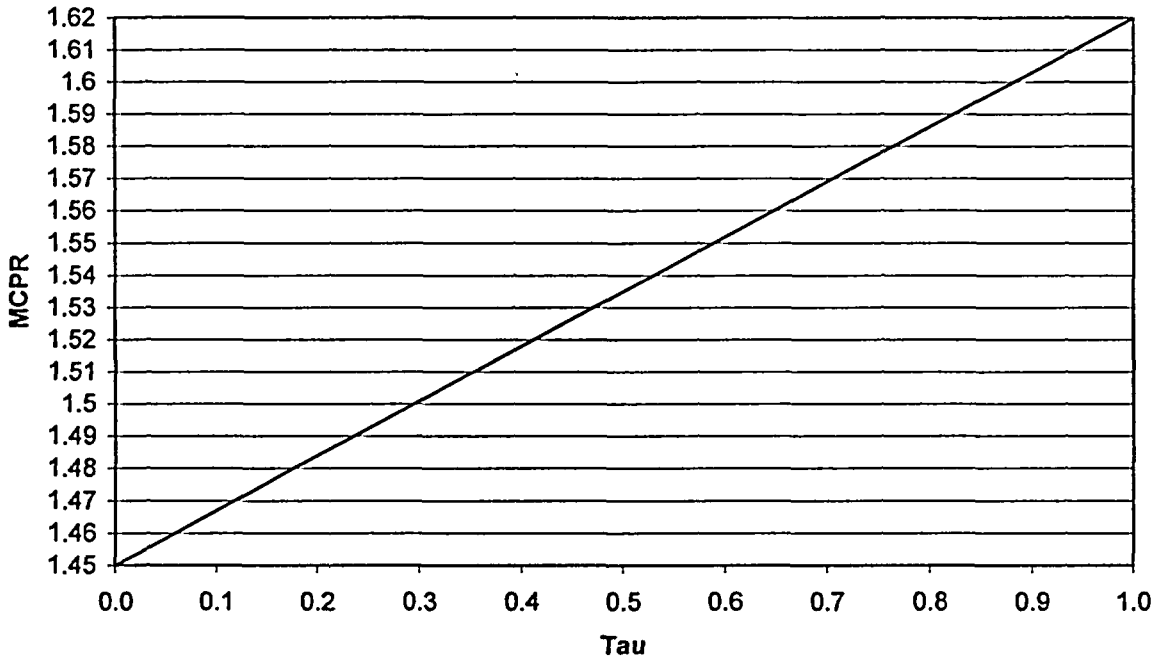


Attachment 17 – OLMCPR(τ) for Beginning of Cycle Until Middle of Cycle*



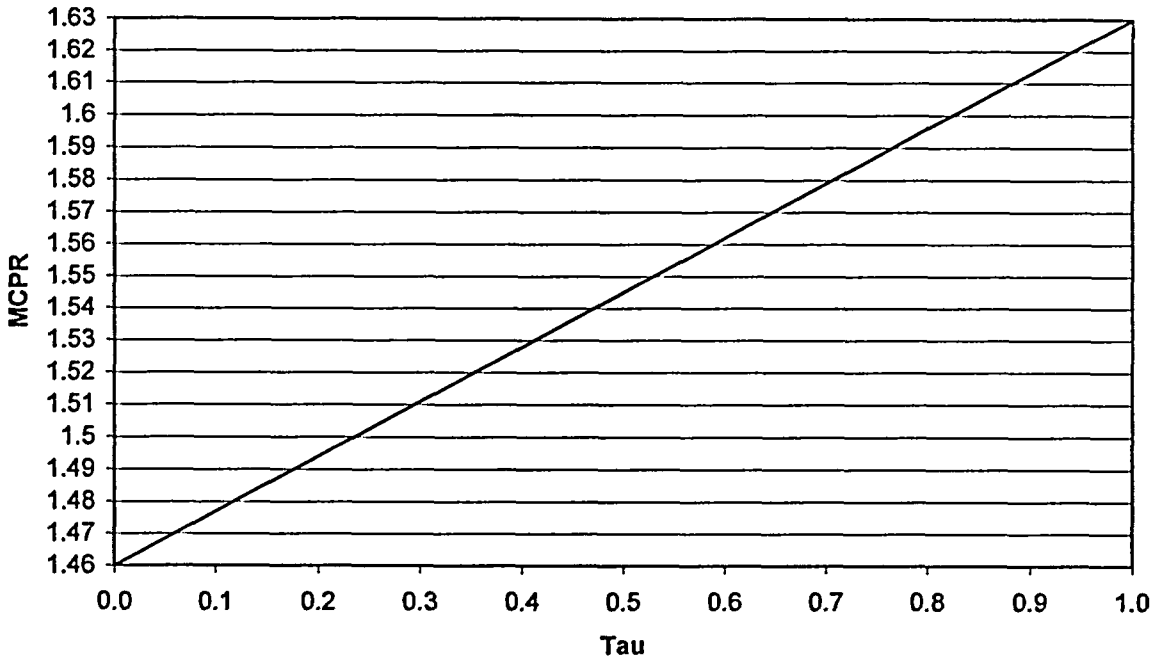
*Middle of Cycle is defined as End of Rated Power (all rods out, rated power, rated flow) minus 2480 MWd/MTU.

Attachment 18 – OLMCPR(τ) for Middle of Cycle* Until End of Cycle

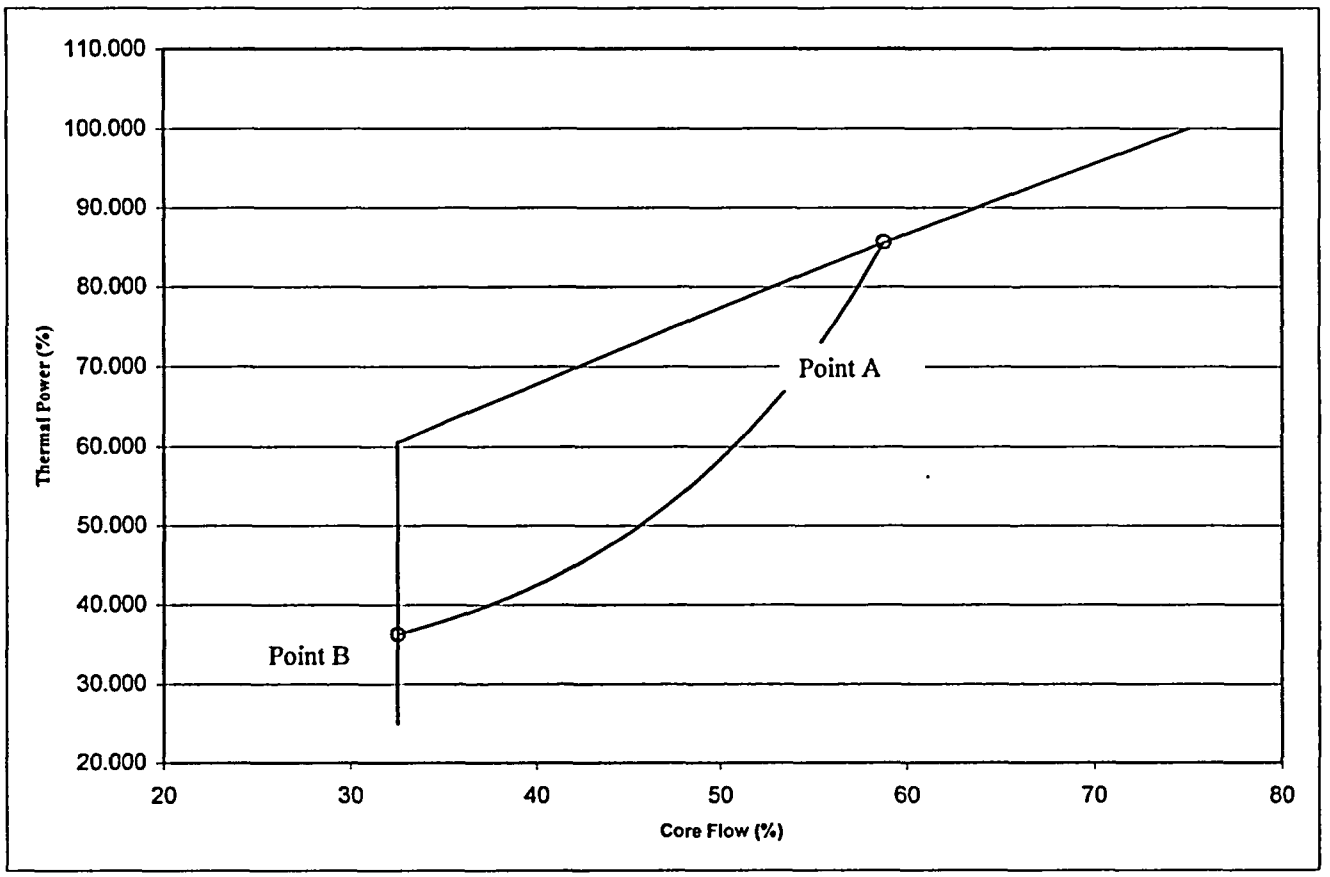


*Middle of Cycle is defined as End of Rated Power (all rods out, rated power, rated flow) minus 2480 MWd/MTU.

Attachment 19 - OLMCPR(τ) with one turbine bypass valve out of service (all exposures)



Attachment 20 – Stability Exclusion Region



Exclusion Region Endpoints	Power (% rated)	Flow (% rated)
A	85.6	58.8
B	36.3	32.5