NEXTera ENERGY DUANE ARNOLD

December 10, 2010

NG-10-0604
TS 5.6.5.d

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Duane Arnold Energy Center (DAEC)
Docket 50-331
License No. DPR-49

Subject: Core Operating Limits Report for DAEC Cycle 23 Operation

In accordance with the requirements of Duane Arnold Energy Center (DAEC) Technical Specifications Section 5.6.5.d, a copy of the Core Operating Limits Report (COLR) for Cycle 23 operation of the DAEC is enclosed.

If you have any questions regarding this matter, please contact Steve Catron, Licensing Manager at (319) 851-7234.

Dean Curtland for

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Vice President, Duane Arnold Energy Center
NextEra Energy Duane Arnold, LLC

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, Duane Arnold Energy Center, USNRC
Resident Inspector, Duane Arnold Energy Center, USNRC

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NRR

Enclosure 1 to
NG-10-0604

DUANE ARNOLD ENERGY CENTER

CYCLE 23

CORE OPERATING LIMITS REPORT

21 pages to follow

Revision 0
September 2010

Duane Arnold Energy Center
Cycle 23
Core Operating Limits Report

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DUANE ARNOLD ENERGY CENTER
CYCLE 23
CORE OPERATING LIMITS REPORT

Revision 0
September 2010

Prepared by:	JB Nuclear Fuels	Date: 9/23/2010
Verified by:	Matt Becht DAEC Reactor Engineering	Date: 9-24-2010
Concurred by:	Manager, Licensing	Date: 9/24/2010
Concurred by:	Manager, Program Engineering	Date: 9/27/2010
Concurred by:	Director, Engineering	Date: 9/27/10
Reviewed by:	2010-2621 Chairman, ORG	Date: 9/30/10
Approved by:	Plant Manager, Nuclear	Date: 9/30/10

1.0 Core Operating Limits Report

This Core Operating Limits Report for Cycle 23 has been prepared in accordance with the requirements of Technical Specification 5.6.5 and is applicable to operation for which rated thermal power is 1912 MWt. The core operating limits have been developed using NRC-approved methodology (Reference 1, as supplemented by References 6 and 7) and are established such that all applicable limits of the plant safety analysis are met. The Cycle 23 values for the core operating limits are provided in Section 3.0 of this report.

2.0 References

1. General Electric Standard Application for Reactor Fuel (GESTAR-II), NEDE-24011-P-A-16, October 2007.

2. Supplemental Reload Licensing Report for Duane Arnold Energy Center, Reload 22 Cycle 23, 0000-0109-9269-SRLR Rev. 0, August 2010.

3. Fuel Bundle Information Report for Duane Arnold Energy Center, Reload 22 Cycle 23, 0000-0109-9269-FBIR Rev. 0, August 2010.

4. Duane Arnold Energy Center Cycle 22 Core Operating Limits Report, Revision 1, September 2009.

5. Duane Arnold Energy Center Asset Enhancement Program, Task T0201: Power/Flow Map, GE-NE-A22-00100-04-01, Revision 0, February 2000.

6. General Electric Licensing Topical Report ODYSY Application for Stability Licensing Calculations Including Option I-D and II Long Term Solutions, NEDE-33213P-A, April 2009.

7. General Electric Report, Plant-Specific Core-Wide Mode DIVOM Procedure Guideline, GE-NE-0000-0031-6498-R0, June 6, 2005.

3.0 Core Operating Limits

1. Average Planar Linear Heat Generation Rate (APLHGR) – TS 3.2.1

   a. The Maximum APLHGR (MAPLHGR) applicable to all fuel types as a function of Planar Average Exposure (PAE) shall not exceed the limiting curves defined by Table 1, multiplied by the smaller of the two MAPFAC/LHGRFAC factors determined from Figures 3 and 4. Figure 1 plots the MAPLHGR curve corresponding to Table 1.

   b. The Maximum Linear Heat Generation Rate (MLHGR) applicable to all fuel rods for all fuel types as a function of Peak Pellet Exposure (PPE) shall not exceed the curves defined by Table 2, multiplied by the smaller of the two MAPFAC/LHGRFAC factors determined from Figures 3 and 4. Figure 2 plots the MLHGR curve for UO_2 fuel rods corresponding to Table 2.

   c. During Single Loop Operation (SLO), the actual MAPLHGR applicable to all fuel types as a function of planar average exposure shall not exceed the limiting curves defined by Table 1, multiplied by the smaller of the two MAPFAC/LHGRFAC factors determined from Figures 3 and 5.

   d. During Single Loop Operation (SLO), the actual MLHGR applicable to all fuel rods for all fuel types as a function of peak pellet exposure shall not exceed the limiting curves defined by Table 2, multiplied by the smaller of the two MAPFAC/LHGRFAC factors determined from Figures 3 and 5.

The above MAPLHGR limits are from the Emergency Core Cooling requirements of the Loss-of-Coolant Accident (LOCA) analyses. The above MLHGR limits are from the fuel thermal-mechanical performance limits. The individual MAPLHGR and MLHGR limits, as discussed in the BASES for TS 3.2.1, are modeled in the process computer. The above can be used to determine the TS MAPLHGR or MLHGR limits in the event the process computer is not available.

2. Minimum Critical Power Ratio (MCPR) – TS 3.2.2

   a. The MCPR shall be equal to or greater than the Operating Limit MCPR (OLMCPR), which is a function of Core Thermal Power, Core Flow, Fuel Design Type (if multiple fuel design types are in the core), and Scram Time (Tau). For Core Thermal Power greater than or equal to 21.7% of rated and less than 40% of rated (21.7% ≤ P < 40%), the OLMCPR is given by Figure 6. For Core Thermal Power greater than or equal to 40% of rated (P ≥ 40%), the OLMCPR is the greater of either:

      i) The applicable flow-dependent OLMCPR determined from Figure 7, or

      ii) The appropriate Rated Power OLMCPR from Figure 8 or 9 [Figure 10 for Recirculation Pump Trip Out-of-Service (RPTOOS); Figure 11 for Turbine Bypass Valves Out-of-Service (TBVOOS); Figure 12 for TBVOOS and RPTOOS], multiplied by the applicable power-dependent OLMCPR multiplier determined from Figure 6.

b. During SLO with Core Thermal Power greater than or equal to 21.7% of rated, the SLO OLMCPR is the greater of either:

   i) adding 0.02 to the OLMCPR determined above, or

   ii) 1.38.

The above can be used to determine the TS OLMCPR limits in the event the process computer is not available.

4.0 Reload Fuel Bundles

FUEL TYPE	CYCLE LOADED	NUMBER
GE14-P10DNAB438-12G6.0-100T-150-T6-2541	21	36
GE14-P10DNAB410-16GZ-100T-150-T6-2919	21	16
GE14-P10DNAB407-18GZ-100T-150-T6-2920	21	12
GE14-P10DNAB405-14GZ-100T-150-T6-3118	22	24
GE14-P10DNAB407-16GZ-100T-150-T6-3119	22	24
GE14-P10DNAB409-16GZ-100T-150-T6-3120	22	16
GE14-P10DNAB413-15GZ-100T-150-T6-3121	22	16
GE14-P10DNAB421-8G7.0/7G6.0-100T-150-T6-3122	22	32
GE14-P10DNAB438-12G6.0-100T-150-T6-2541	22	40
GE14-P10DNAB421-14G7.0-100T-150-T6-3301	23	16
GE14-P10DNAB410-16GZ-100T-150-T6-3303	23	56
GE14-P10DNAB411-14G8.0-100T-150-T6-3304	23	32
GE14-P10DNAB397-15GZ-100T-150-T6-3307	23	16
GE14-P10DNAB438-12G6.0-100T-150-T6-2541	23	32

All Cycle 23 fuel types are of the GE14 fuel design type. Note that the bundle GE14-P10DNAB438-12G6.0-100T-150-T6-2541 loaded in Cycle 23 is identical to the assembly of the same name that was loaded in Cycles 21 and 22.

5.0 Thermal-Hydraulic Stability

a. Continued reactor operation within the "Exclusion Region" on the power/flow map, as defined on Figure 13, is not permitted. (Surveillance Requirement 3.4.1.2)

b. Continued reactor operation within the "Buffer Region" on the power/flow map, as defined in Figure 13, is not permitted when the thermal-hydraulic stability monitor (SOLOMON) is not operational.

Please see References 6 and 7 for more information on Thermal-Hydraulic Stability.

TABLE 1

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) Limit
as a Function of Planar Average Exposure

for

All Cycle 23 Fuel Types

Planar Average Exposure (GWd/ST)	MAPLHGR Limit (kW/ft)
0.00	12.82
19.13	12.82
57.61	8.00
63.50	5.00

TABLE 2

Maximum Linear Heat Generation Rate (MLHGR) Limit
as a Function of Peak Pellet Exposure

for

All Cycle 23 Fuel Types

Peak Pellet Exposure	UO_2 MLHGR Limit
GWD/MT (GWD/ST)	kW/ft
0 (0)	13.4
16.0 (14.51)	13.4
63.5 (57.61)	8.0
70.0 (63.50)	5.0

2% Gd_2O_3 Rods			
Peak Pellet Exposure	0% Zone MLHGR Limit	Peak Pellet Exposure	2% Zone MLHGR Limit
GWD/MT (GWD/ST)	kW/ft	GWD/MT (GWD/ST)	kW/ft
0 (0)	12.800	0 (0)	13.093
15.284 (13.865)	12.800	13.722 (12.448)	13.093
60.657 (55.027)	7.642	61.377 (55.680)	7.816
66.866 (60.660)	4.776	67.898 (61.596)	4.885

TABLE 2 (continued)

6% Gd_2O_3 Rods			
Peak Pellet Exposure	**0% Zone MLHGR Limit**	**Peak Pellet Exposure**	**6% Zone MLHGR Limit**
GWD/MT (GWD/ST)	kW/ft	GWD/MT (GWD/ST)	kW/ft
0 (0)	13.100	0 (0)	12.255
15.642 (14.190)	13.100	13.532 (12.276)	12.255
62.078 (56.316)	7.821	60.625 (54.998)	7.316
68.433 (62.081)	4.888	67.069 (60.844)	4.572

7% Gd_2O_3 Rods			
Peak Pellet Exposure	**0% Zone MLHGR Limit**	**Peak Pellet Exposure**	**7% Zone MLHGR Limit**
GWD/MT (GWD/ST)	kW/ft	GWD/MT (GWD/ST)	kW/ft
0 (0)	13.200	0 (0)	12.000
15.761 (14.298)	13.200	13.419 (12.174)	12.000
62.552 (56.746)	7.881	60.174 (54.589)	7.164
68.955 (62.555)	4.925	66.572 (60.393)	4.478

8% Gd_2O_3 Rods			
Peak Pellet Exposure	**0% Zone MLHGR Limit**	**Peak Pellet Exposure**	**8% Zone MLHGR Limit**
GWD/MT (GWD/ST)	kW/ft	GWD/MT (GWD/ST)	kW/ft
0 (0)	13.200	0 (0)	11.755
15.761 (14.298)	13.200	13.315 (12.079)	11.755
62.552 (56.746)	7.881	59.761 (54.214)	7.018
68.955 (62.555)	4.925	66.117 (59.980)	4.386

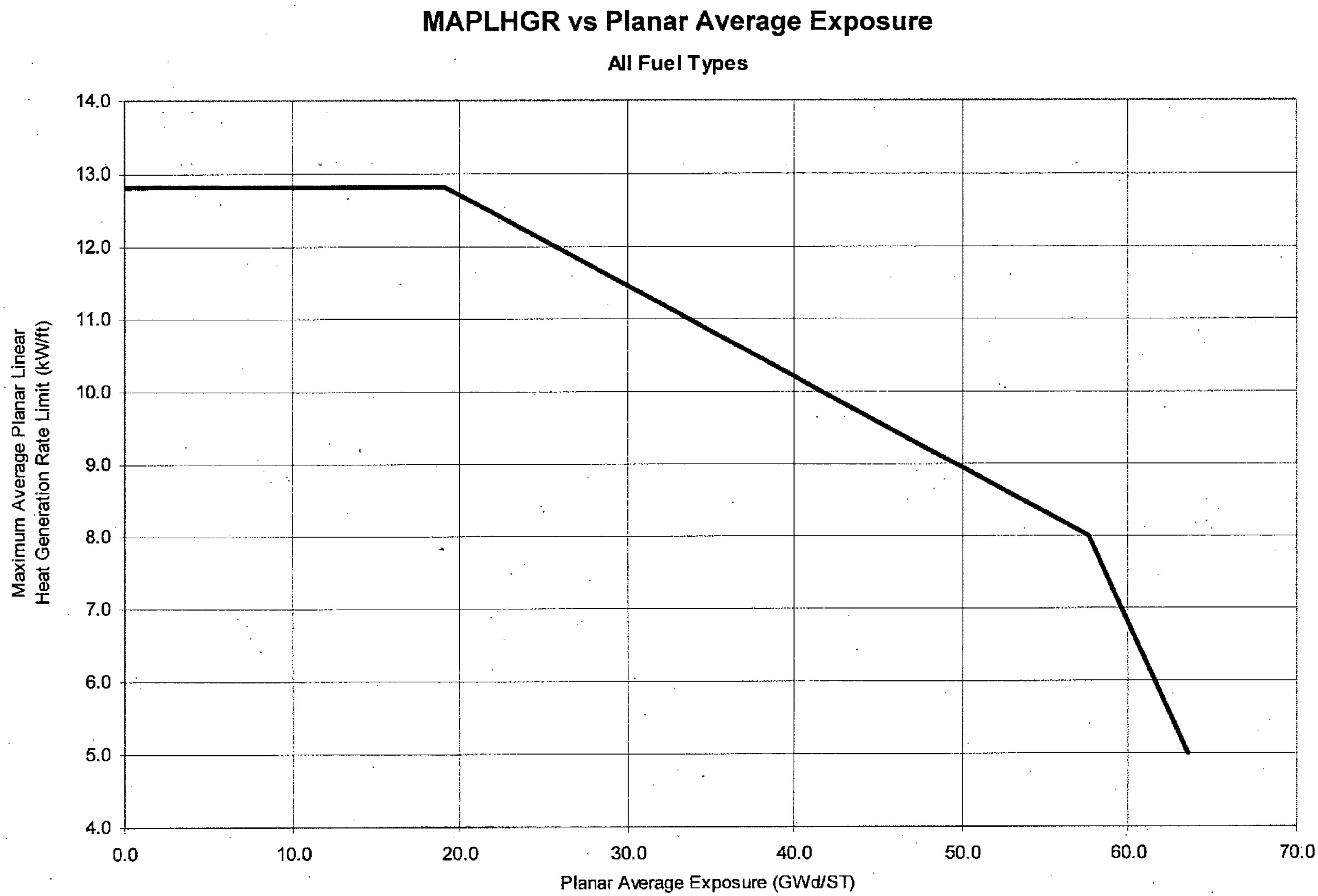

MAPLHGR vs Planar Average Exposure
All Fuel Types
Maximum Average Planar Linear Heat Generation Rate Limit (kW/ft)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Planar Average Exposure (GWd/ST)

Figure 1

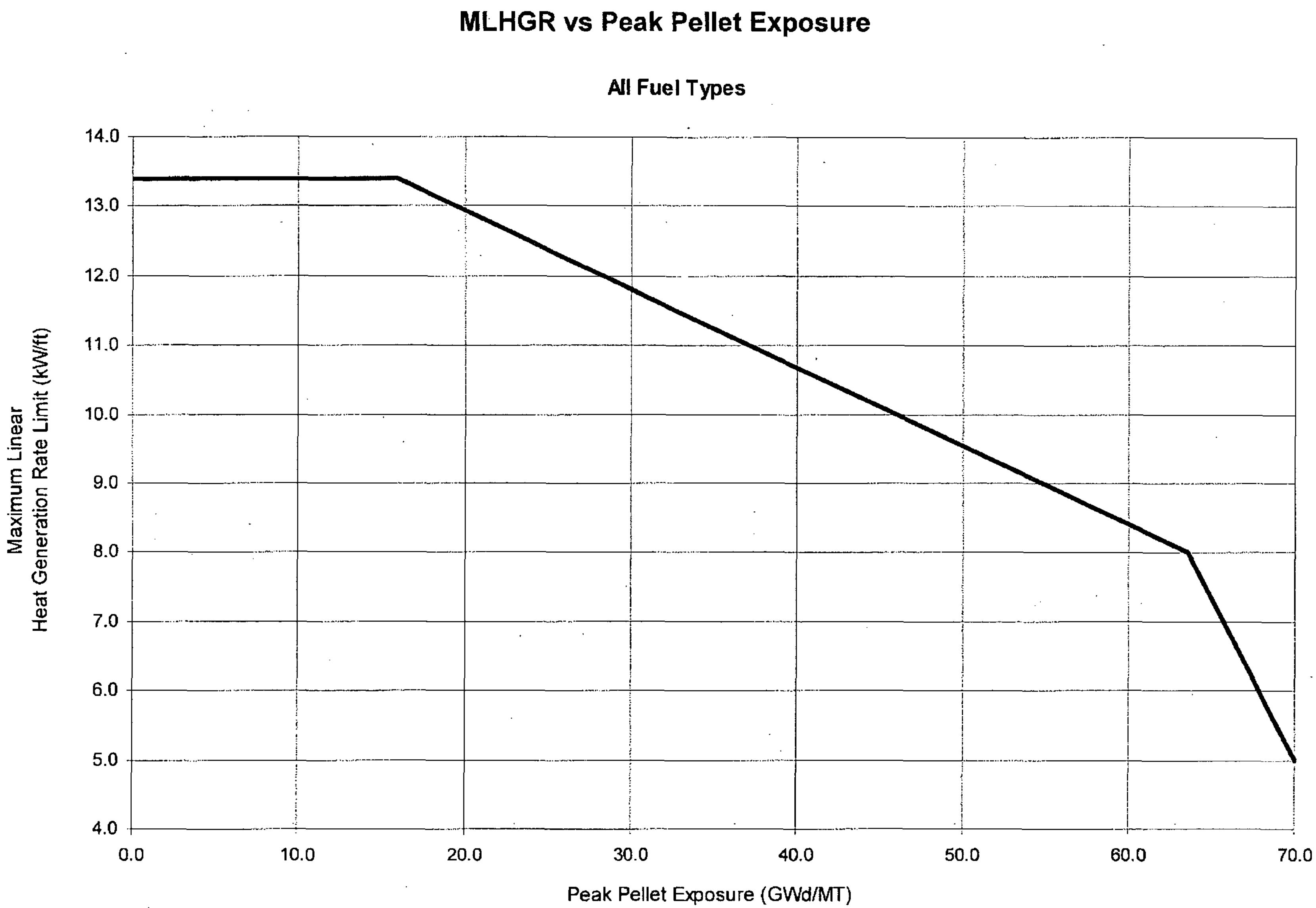

MLHGR vs Peak Pellet Exposure
All Fuel Types
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
Maximum Linear
Heat Generation Rate Limit (kW/ft)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Peak Pellet Exposure (GWd/MT)

Figure 2

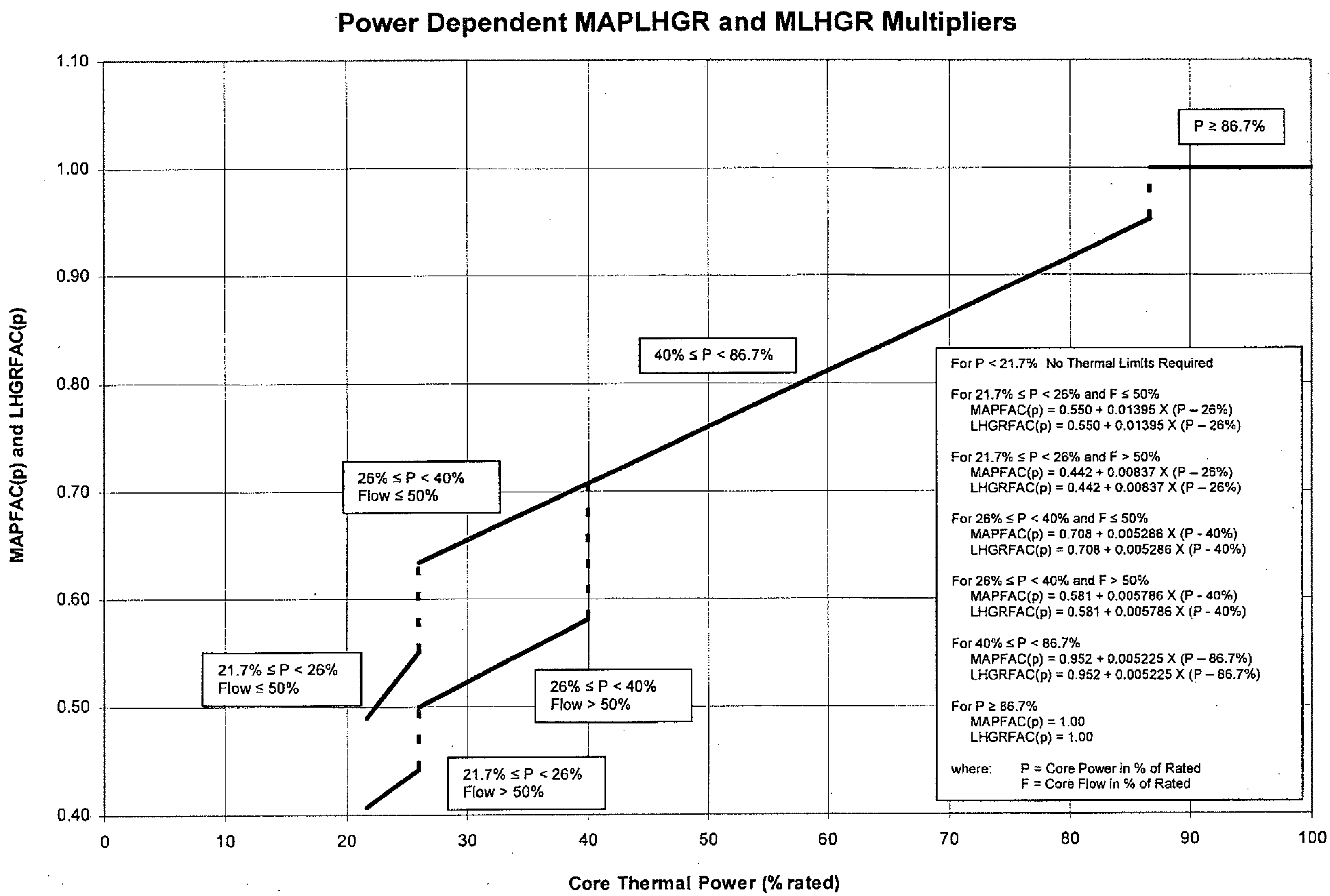

Power Dependent MAPLHGR and MLHGR Multipliers
MAPFAC(p) and LHGRFAC(p)
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0
10
20
30
40
50
60
70
80
90
100
Core Thermal Power (% rated)
P ≥ 86.7%
40% ≤ P < 86.7%
26% ≤ P < 40%
Flow ≤ 50%
21.7% ≤ P < 26%
Flow ≤ 50%
26% ≤ P < 40%
Flow > 50%
21.7% ≤ P < 26%
Flow > 50%
For P < 21.7% No Thermal Limits Required
For 21.7% ≤ P < 26% and F ≤ 50%
MAPFAC(p) = 0.550 + 0.01395 X (P – 26%)
LHGRFAC(p) = 0.550 + 0.01395 X (P – 26%)
For 21.7% ≤ P < 26% and F > 50%
MAPFAC(p) = 0.442 + 0.00837 X (P – 26%)
LHGRFAC(p) = 0.442 + 0.00837 X (P – 26%)
For 26% ≤ P < 40% and F ≤ 50%
MAPFAC(p) = 0.708 + 0.005286 X (P - 40%)
LHGRFAC(p) = 0.708 + 0.005286 X (P - 40%)
For 26% ≤ P < 40% and F > 50%
MAPFAC(p) = 0.581 + 0.005786 X (P - 40%)
LHGRFAC(p) = 0.581 + 0.005786 X (P - 40%)
For 40% ≤ P < 86.7%
MAPFAC(p) = 0.952 + 0.005225 X (P – 86.7%)
LHGRFAC(p) = 0.952 + 0.005225 X (P – 86.7%)
For P ≥ 86.7%
MAPFAC(p) = 1.00
LHGRFAC(p) = 1.00
where: P = Core Power in % of Rated
F = Core Flow in % of Rated

Figure 3

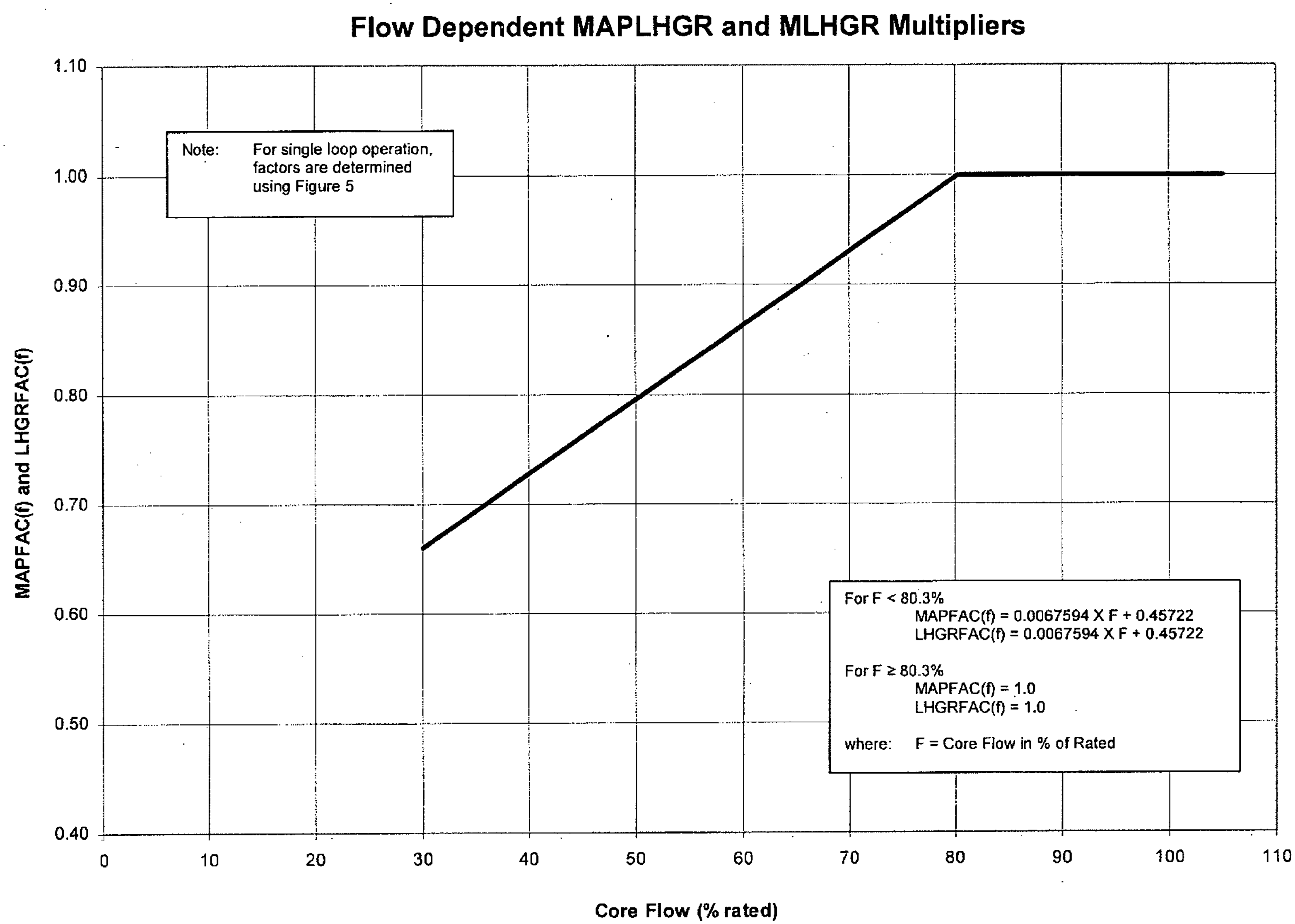
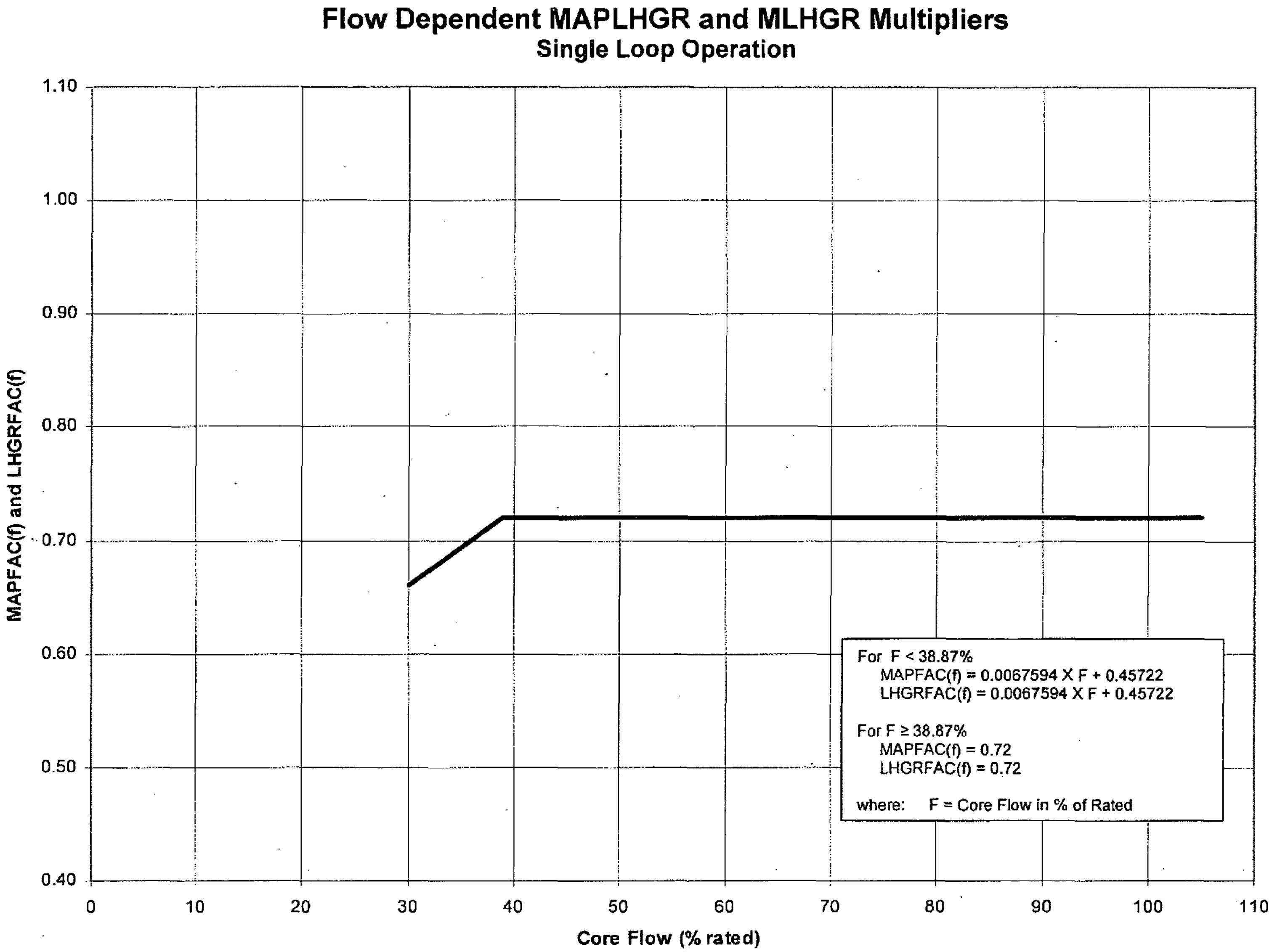

Flow Dependent MAPLHGR and MLHGR Multipliers
MAPFAC(f) and LHGRFAC(f)
Core Flow (% rated)
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0
10
20
30
40
50
60
70
80
90
100
110
Note: For single loop operation, factors are determined using Figure 5
For F < 80.3%
MAPFAC(f) = 0.0067594 X F + 0.45722
LHGRFAC(f) = 0.0067594 X F + 0.45722
For F ≥ 80.3%
MAPFAC(f) = 1.0
LHGRFAC(f) = 1.0
where: F = Core Flow in % of Rated

Figure 4



Flow Dependent MAPLHGR and MLHGR Multipliers
Single Loop Operation
MAPFAC(f) and LHGRFAC(f)
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0
10
20
30
40
50
60
70
80
90
100
110
Core Flow (% rated)
For F < 38.87%
MAPFAC(f) = 0.0067594 X F + 0.45722
LHGRFAC(f) = 0.0067594 X F + 0.45722
For F ≥ 38.87%
MAPFAC(f) = 0.72
LHGRFAC(f) = 0.72
where: F = Core Flow in % of Rated

Figure 5

Power Dependent OLMCPR Limits and Multipliers

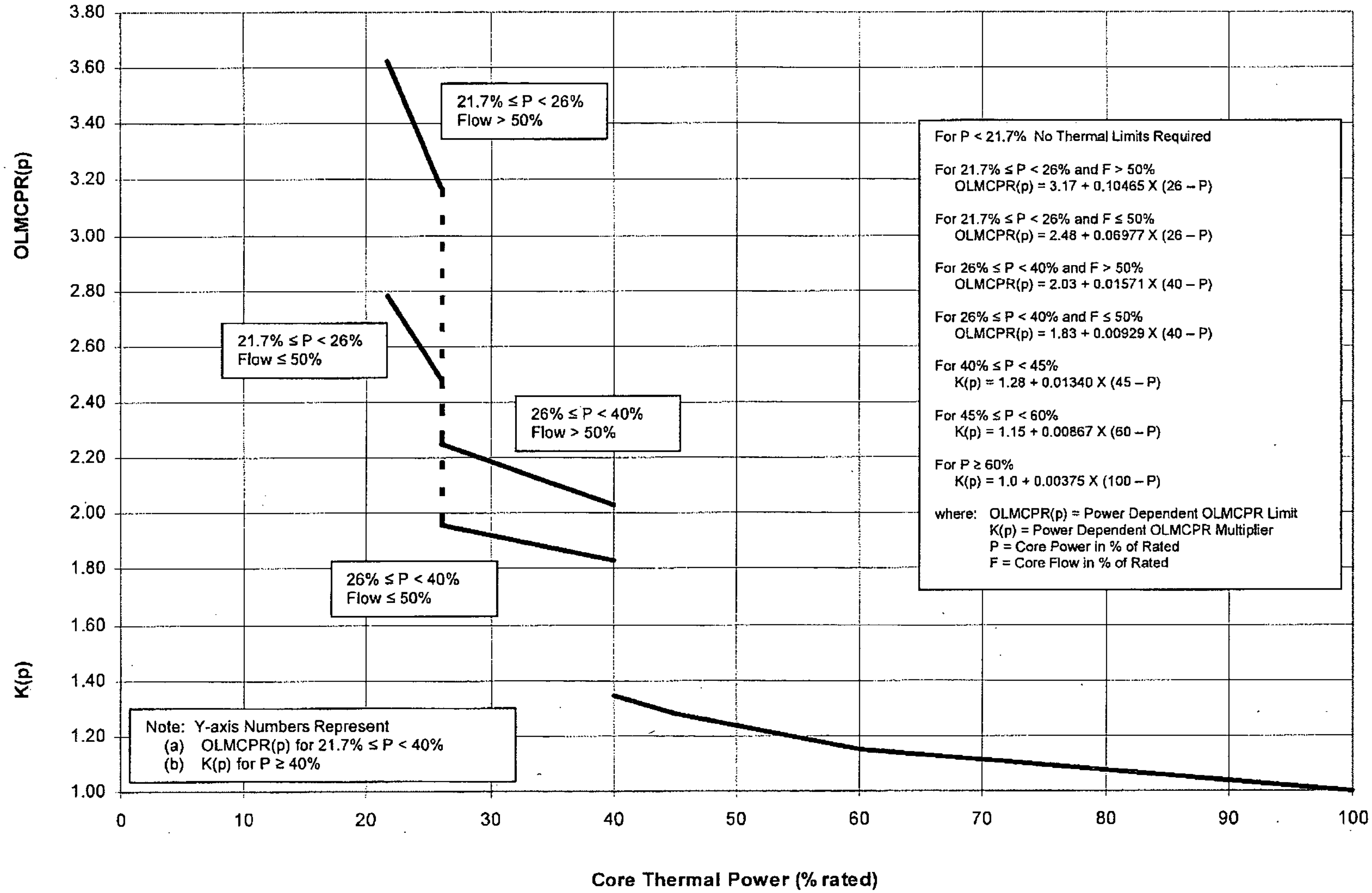


Figure 6

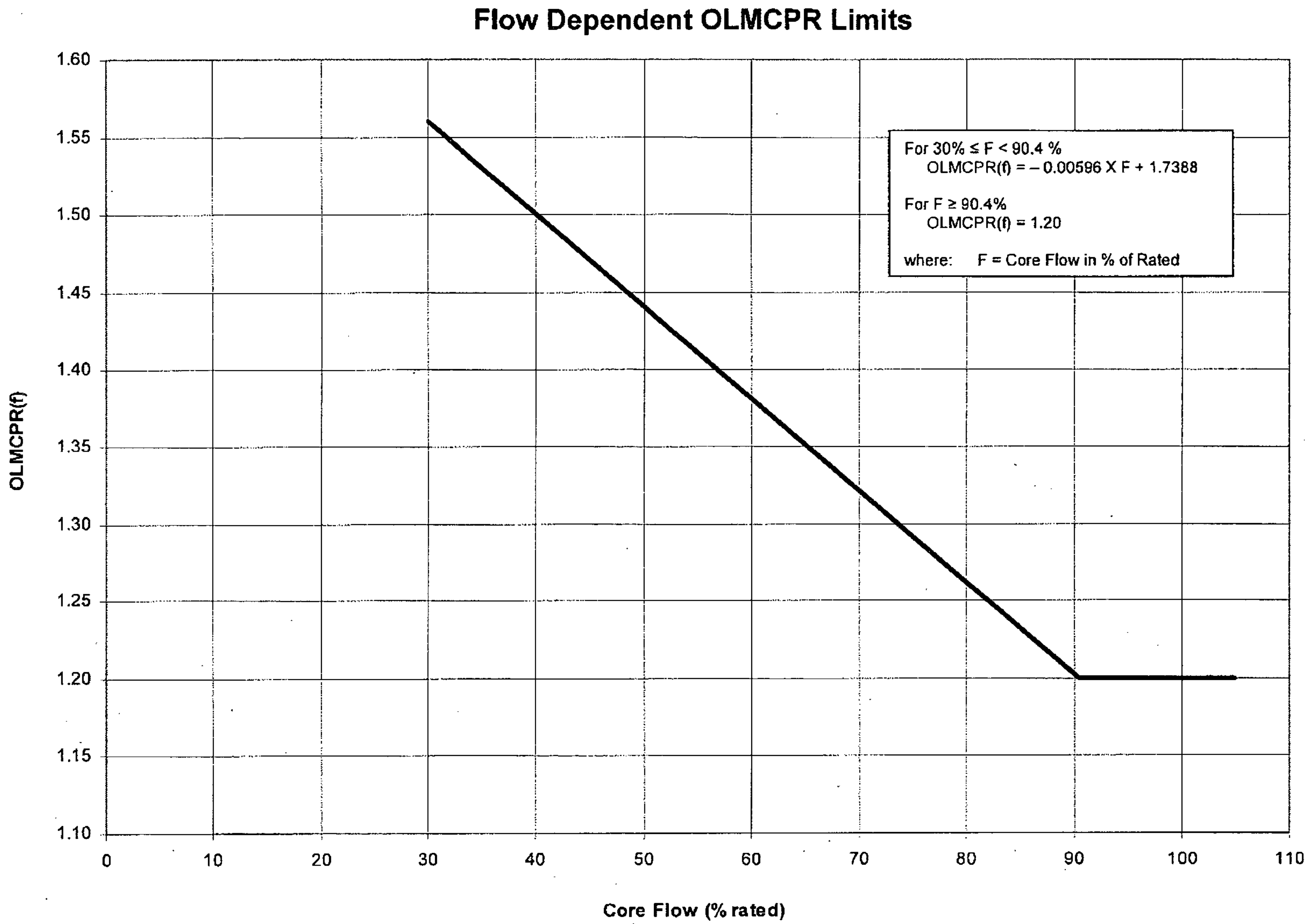

Flow Dependent OLMCPR Limits
OLMCPR(f)
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
0
10
20
30
40
50
60
70
80
90
100
110
Core Flow (% rated)
For 30% ≤ F < 90.4 %
OLMCPR(f) = – 0.00596 X F + 1.7388
For F ≥ 90.4%
OLMCPR(f) = 1.20
where: F = Core Flow in % of Rated

Figure 7

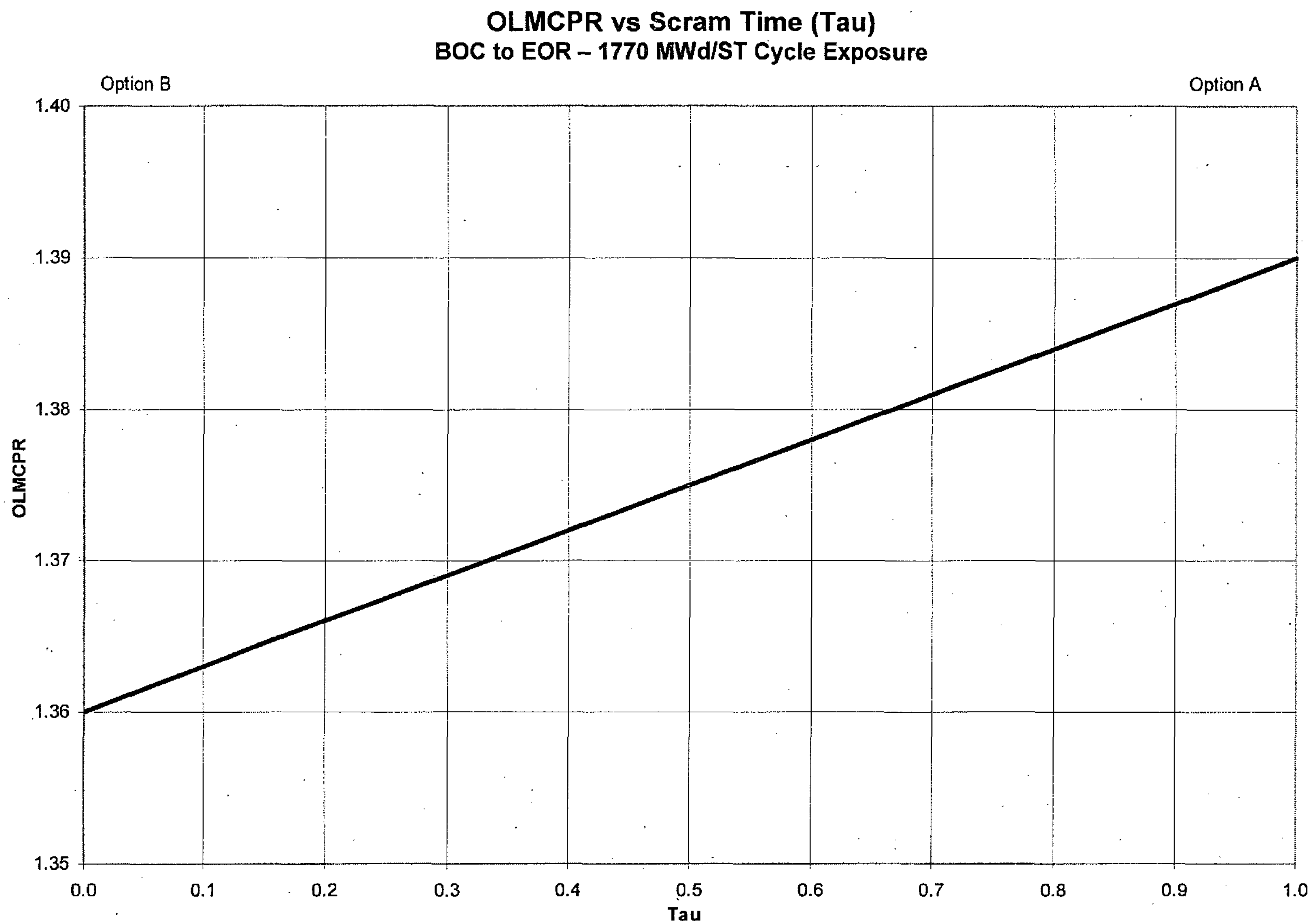

OLMCPR vs Scram Time (Tau)
BOC to EOR – 1770 MWd/ST Cycle Exposure
Option B
Option A
1.40
1.39
1.38
1.37
1.36
1.35
OLMCPR
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Tau

Figure 8

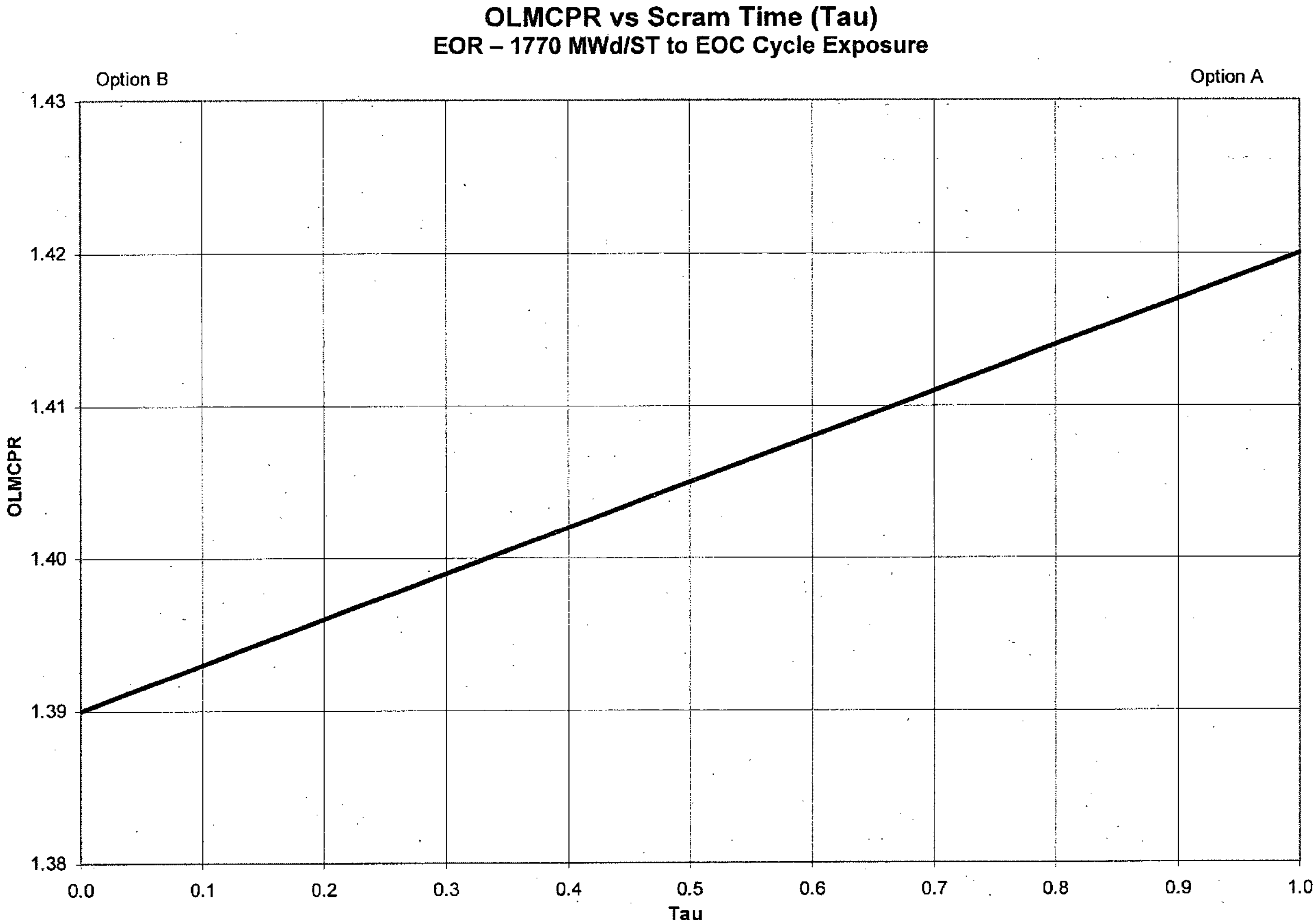

OLMCPR vs Scram Time (Tau)
EOR – 1770 MWd/ST to EOC Cycle Exposure
Option B
Option A
1.43
1.42
1.41
1.40
1.39
1.38
OLMCPR
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Tau

Figure 9

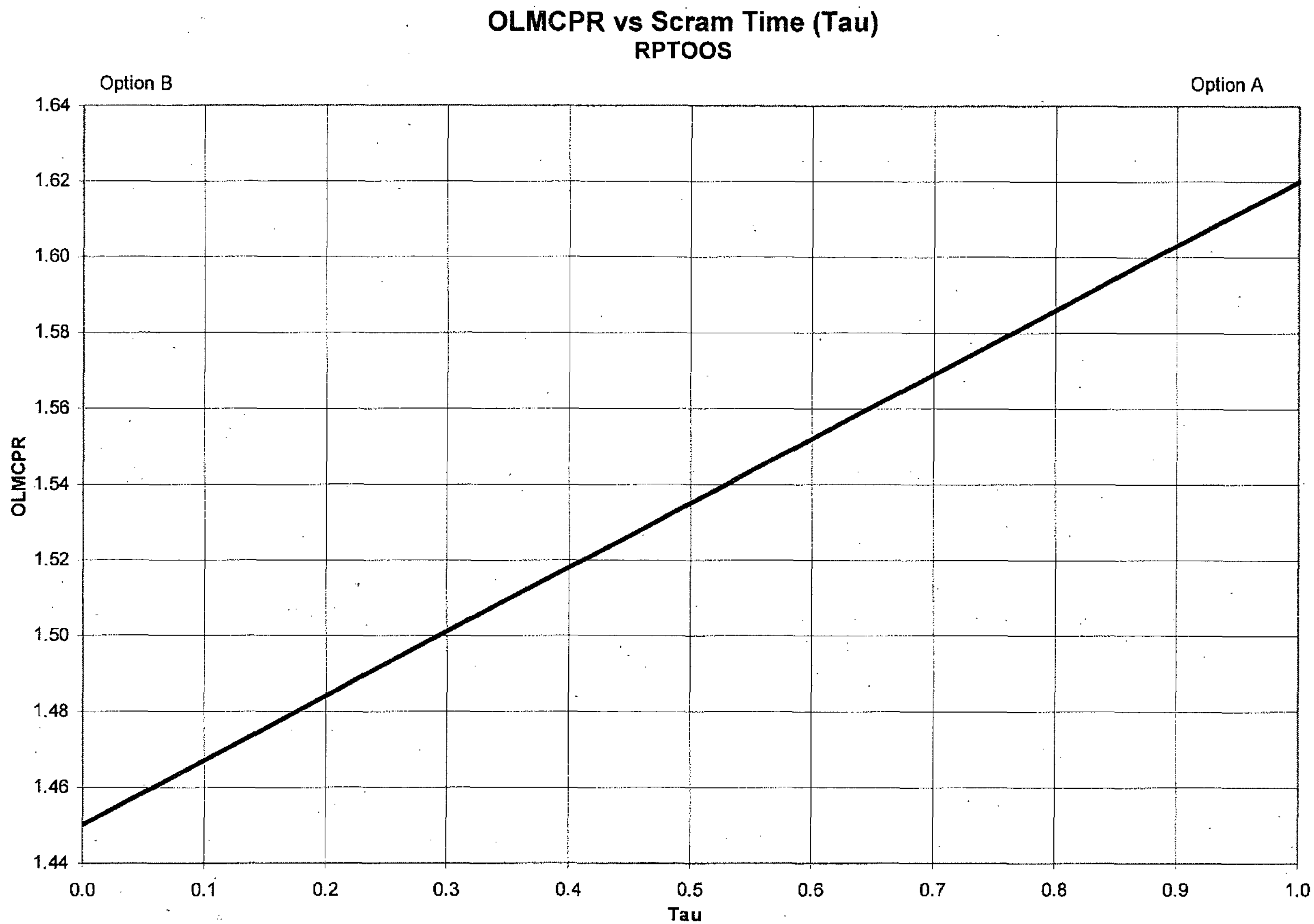

OLMCPR vs Scram Time (Tau)
RPTOOS
Option B
Option A
1.64
1.62
1.60
1.58
1.56
1.54
1.52
1.50
1.48
1.46
1.44
OLMCPR
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Tau

Figure 10

OLMCPR vs Scram Time (Tau)
TBVOOS

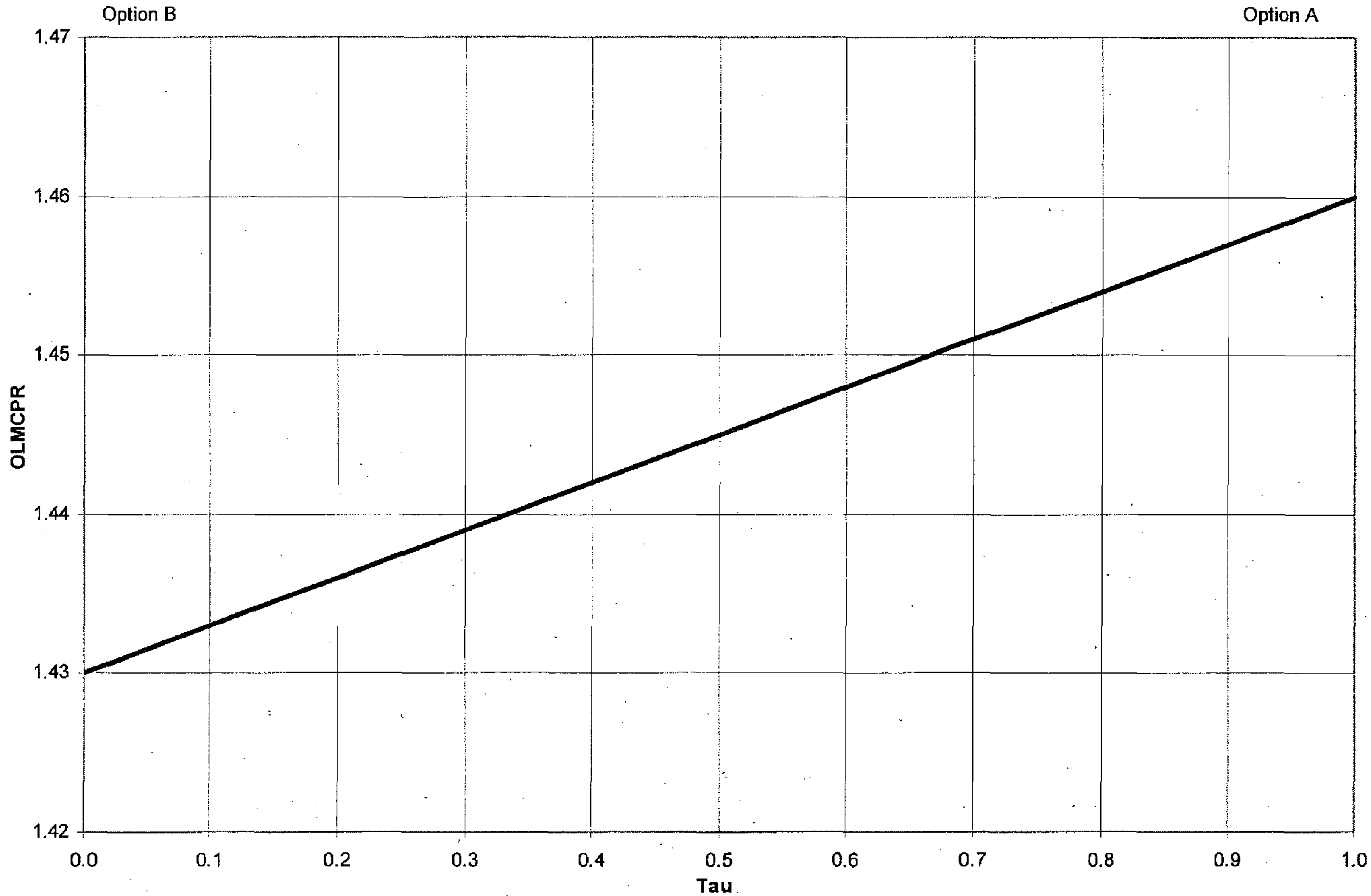


Figure 11

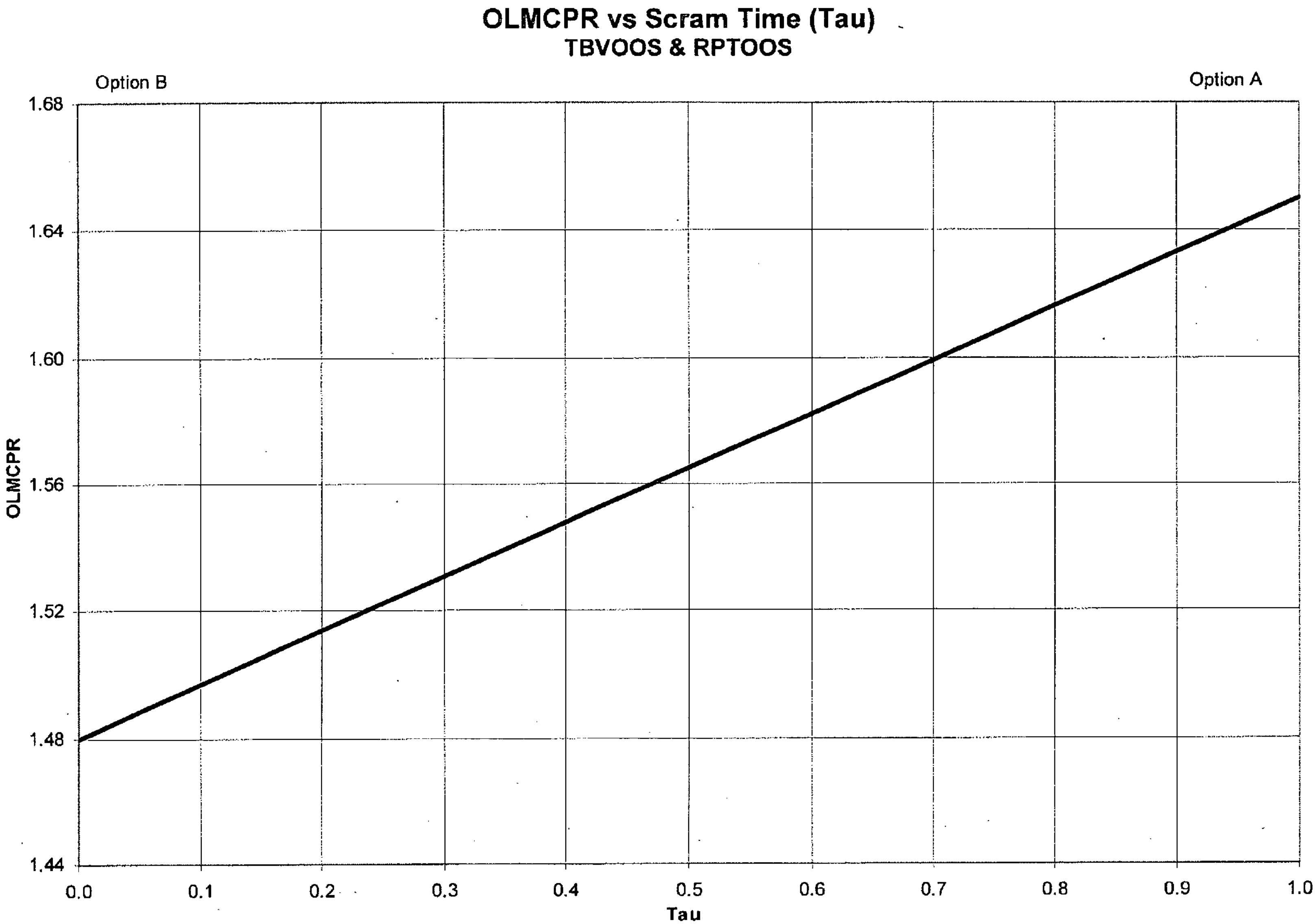

OLMCPR vs Scram Time (Tau)
TBVOOS & RPTOOS
Option B
Option A
1.68
1.64
1.60
1.56
1.52
1.48
1.44
OLMCPR
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Tau

Figure 12

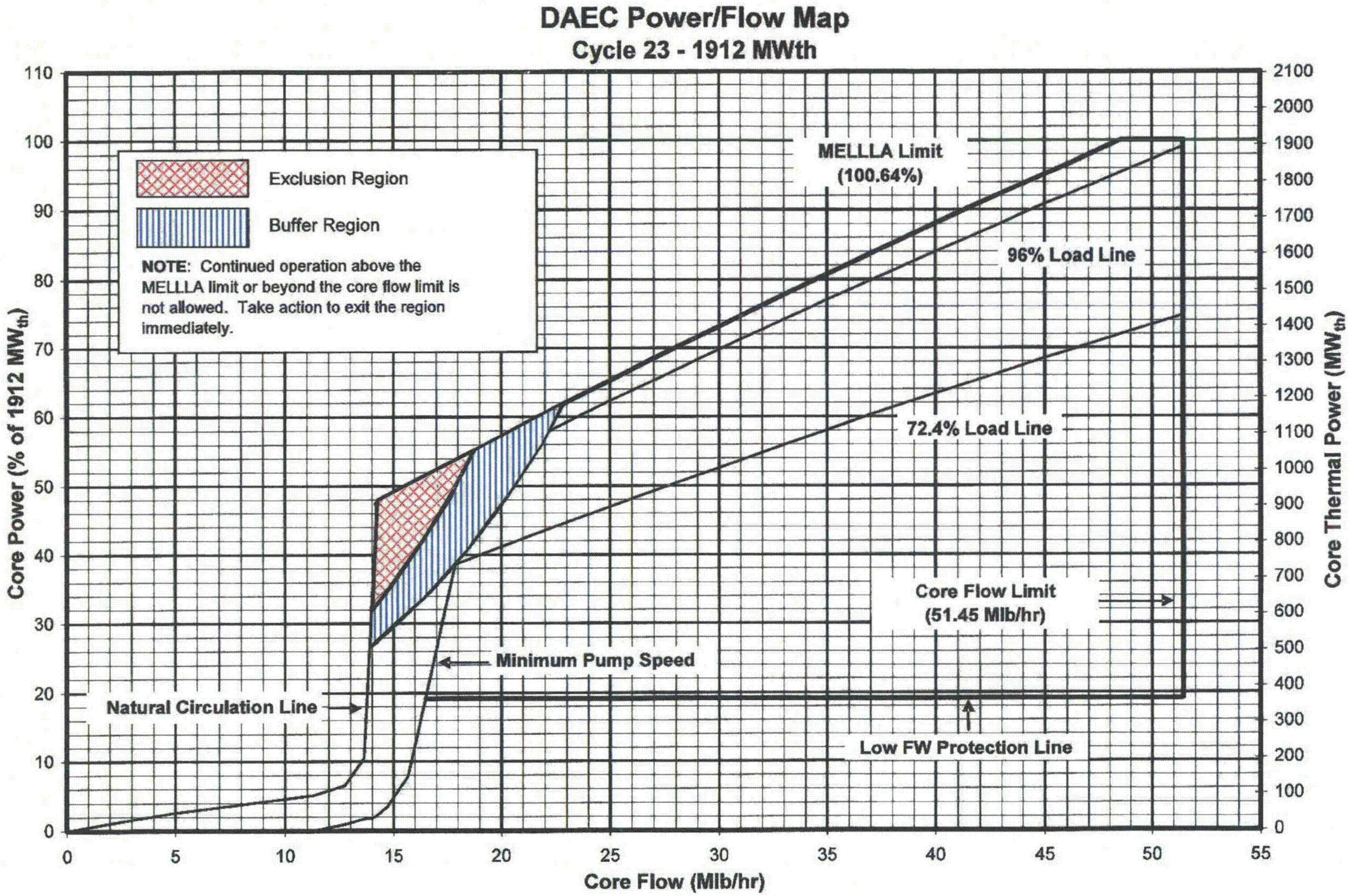

DAEC Power/Flow Map
Cycle 23 - 1912 MWth
Exclusion Region
Buffer Region
NOTE: Continued operation above the MELLLA limit or beyond the core flow limit is not allowed. Take action to exit the region immediately.
MELLLA Limit
(100.64%)
96% Load Line
72.4% Load Line
Core Flow Limit
(51.45 Mlb/hr)
Minimum Pump Speed
Natural Circulation Line
Low FW Protection Line
Core Power (% of 1912 MWth)
Core Thermal Power (MWth)
Core Flow (Mlb/hr)
0
5
10
15
20
25
30
35
40
45
50
55
0
10
20
30
40
50
60
70
80
90
100
110
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

Figure 13