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TMI-11-157
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TS 6.9.5.4

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington DC 20555

Three Mile Island Nuclear Station, Unit 1
Renewed Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Cycle 19 Core Operating Limits Report, COLR TMI 1, Revision 8

Enclosed is a copy of the Cycle 19 Core Operating Limits Report, COLR TMI 1, Revision 8. The Cycle 19 Core Operating Limits Report, COLR TMI 1, Revision 8, provides the cycle-specific limits established to support operations of Cycle 19 up to 713 Effective Full Power Days. The cycle-specific core operating limits contained in this report have been determined in accordance with Technical Specification 6.9.5.

This COLR is being submitted to the NRC in accordance with the TMI Unit 1 Technical Specifications Section 6.9.5.4.

If you have any questions, please do not hesitate to contact us.

Respectively,

Tracy A. Quald for

David W. Atherholt
Regulatory Assurance Manager, Three Mile Island Unit 1
Exelon Generation Co., LLC

DWA/awm

Enclosure: Cycle 19 Core Operating Limits Report, COLR TMI 1, Revision 8

cc: Administrator, Region 1, USNRC
USNRC Senior Resident Inspector, TMI Unit 1
USNRC Project Manager, TMI Unit 1

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NRR

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TMI-1 Cycle 19
Core Operating Limits Report

COLR TMI 1
Rev. 8

R. Jaffa	Preparer	10-17-11 Date
M. Mahgerefteh	Reviewer / SQR	10/18/11 Date
T. Stevens	NF Approver	10/21/11 Date
W. Stanley	ISR	24 Oct 2011 Date
W. Carsky	Director, Site Engineering	10/26/11 Date

TABLE OF CONTENTS

ABSTRACT

This Core Operating Limits Report (COLR) has been prepared in accordance with the requirements of TMI-1 Technical Specification 6.9.5. The core operating limits were generated using the methodologies described in References 1 and 2 and were documented in Reference 3. The core operating limits and reactor protection system limits and setpoints in this report have been analyzed for a maximum end-of-cycle (EOC) length of 713 EFPD.

The Full Incore System (FIS) operability requirements contained within describe the number and location of Self-Powered Neutron Detector (SPND) strings that must be operable in order to monitor imbalance and quadrant tilt using the FIS.

Quadrant tilt limits for FIS, out-of-core detector [OCD] system and minimum incore system [MIS] are given in Table 1. Technical Specification requirements related to quadrant tilt, including operator actions that must be taken in the event quadrant tilt limits are exceeded, are stated in T.S. 3.5.2.4.

Rod insertion limits are provided in Figures 1 to 3 to ensure that the safety criteria for DNBR protection, LOCA kw/ft limits, shutdown margin and ejected rod worth are met. Technical Specification requirements related to control rod positions, including operator actions that must be taken in the event control rod positions enter Restricted or Not Allowed Regions, are stated in T.S. 3.5.2.5.

Imbalance limits for FIS, OCD and MIS are given in Figures 4 to 8. Technical Specification requirements related to axial power imbalance, including operator actions that must be taken in the event imbalance enters the Restricted Region, are stated in T.S. 3.5.2.7.

COLR Figures 1 through 8 may have three distinctly defined regions:

1. Permissible Region
2. Restricted Region
3. Not Allowed Region (Operation in this region is not allowed)

The limiting criteria within the Restricted Region are ECCS power peaking, initial condition DNB peaking, and potential ejected rod worth. Since the probability of accidents related to these criteria is very low, especially in a twenty-four (24) hour time frame, inadvertent operation within the Restricted Region for a period not exceeding twenty-four (24) hours is allowed [T.S. 3.5.2.5.b and 3.5.2.7.e], provided that hot channel factors are within the limits given in Tables 2 and 3. Similarly, continued operation with quadrant tilt greater than the steady-state tilt limit for a period not exceeding twenty-four

(24) hours is allowed [T.S. 3.5.2.4.e] provided that hot channel factors are within the limits given in Tables 2 and 3, with the added requirement that reactor power must be reduced 2% for each 1% tilt in excess of the tilt limit [T.S. 3.5.2.4.d]. (Note that continued operation with quadrant tilt greater than the steady-state tilt limit is also permitted without hot channel factor verification as long as the alternate guidance in T.S. 3.5.2.4.e is followed).

The limiting criterion within the Not Allowed Region is the shutdown margin limit. Inadvertent operation in this region is not permitted and requires immediate action to exit the region. Acceptable control rod positions shall be attained within two (2) hours [T.S. 3.5.2.5.b.2].

Table 2 contains the total peaking hot channel factor $F_Q(Z)$ limits (i.e., ECCS power peaking limits) for core monitoring. Table 3 contains the nuclear enthalpy rise hot channel factor $F^N_{\Delta H}$ limits (i.e., initial condition DNB peaking) for core monitoring. During normal conditions, operation within quadrant tilt (Table 1), rod insertion (Figures 1-3), and imbalance (Figures 4-8) limits ensure $F_Q(Z)$ and $F^N_{\Delta H}$ limits are met. However, verification that positive margin to $F_Q(Z)$ and $F^N_{\Delta H}$ limits exists may be required during the following abnormal conditions:

T.S. 3.5.2.2.e (operation with an inoperable rod)
T.S. 3.5.2.4.e (operation with quadrant tilt in excess of steady-state limits)
T.S. 3.5.2.5.b (operation with control rods in the Restricted Region)
T.S. 3.5.2.7.d (operation with imbalance in the Restricted Region)

Display 4 of the Core Monitoring System provides the minimum margin to $F_Q(Z)$ limits on the Thermal Limiting Condition Core Summary page and to $F^N_{\Delta H}$, limits on the Thermal Limiting Condition Hot Channel Factor page.

COLR Figure 9 indicates the LOCA limited maximum allowable linear heat rates as a function of fuel rod burnup and fuel elevation for the Mark-B-HTP fuel type. Bounding values for monitoring these limits for the current cycle in terms of fuel batch, fuel rod burnup and core elevation are listed in Table 2. The full power linear heat rate limits are applicable for partial-power and three-pump operation since the allowable moderator temperature coefficient (MTC) as a function of power, shown on page 4 of Figure 9, is preserved by the cycle design.

COLR Figure 10 provides the Axial Power Imbalance Protective Limits (APIPL) that preserve the DNBR and Centerline Fuel Melt design criteria.

COLR Figure 11 provides the Protection System Maximum Allowable Setpoints for Axial Power Imbalance which combine the power/flow and error-adjusted axial imbalance trip setpoints that ensure the APIPL of Figure 10 are not exceeded.

Enclosure 1 contains operating limits not required by TS. The Maximum Allowable Local Linear Heat Rate limits are monitored by the Process Computer core monitoring system software as part of the bases of the required limits and setpoints. The minimum boron volumes and concentrations for the Boric Acid Mix Tank (BAMT) and Reclaimed Boric Acid Storage Tanks (RBAT) are the boron levels needed to achieve cold shutdown conditions throughout the cycle using these tanks.

Enclosure 2 contains the bases descriptions of the Power-to-Flow Trip Setpoint to prevent violation of DNBR criteria and the Design Nuclear Power Peaking Factors for axial flux shape ($F^N{}_Z$) and hot channel nuclear enthalpy rise ($F^N{}_{\Delta H}$) that define the reference design peaking condition in the core.

Full Incore System (FIS) Operability Requirements

- The Full Incore System (FIS) is operable for monitoring axial power imbalance provided the number of valid Self Powered Neutron Detector (SPND) signals in any one quadrant is not less than 75% of the total number of SPNDs in the quadrant.

Quadrant	SPNDs	75%
WX	85.75	64.5
XY	99.75	75.0
YZ	89.25	67.0
ZW	89.25	67.0

- The Full Incore System (FIS) is operable for monitoring quadrant tilt provided the number of valid symmetric string individual SPND signals in any one quadrant is not less than 75% (21) of the total number of SPNDs in the quadrant (28).

Quadrant	Symmetric Strings
WX	7, 9, 32, 35
XY	5, 23, 25, 28
YZ	16, 19, 47, 50
ZW	11, 13, 39, 43

Source Doc.: B&W 86-1172640-00
Referred to by: Tech. Spec. 3.5.2.4.a and 3.5.2.7.a

TABLE 1
Error-Adjusted Quadrant Tilt Limits

	Steady State Limit 15 < Power ≤ 60%	Steady State Limit Power > 60%	Maximum Limit Power > 15%
Full Incore System (FIS)	6.83	3.94	16.8
Minimum Incore System (MIS)[a]	2.78 (2.19)	1.90 (1.50)	9.5

(a) Limits are based on the condition that no individual long emitter detector affecting the minimum in-core tilt calculation exceeds 73% sensitivity depletion. If 73% sensitivity depletion is exceeded, the limits must be reduced to the values in parentheses ( ).

Note: If the Full Incore System (FIS) is inoperable, FIS tilt limits are applicable to the Out-of-Core (OCD) Detector System following the guidance in OP-TM-300-202, Quadrant Power Tilt and Axial Power Imbalance using the Out-of-Core Detector System.

Referred to by: Tech. Spec. 3.5.2.4

TABLE 2
Core Monitoring System Bounding Values for LOCA Limited Maximum Allowable Linear Heat Rate (kW/ft [a])

UO_2 LOCA Limits

Batches 19, 20 (Except Batch 20A and 20B), and 21[b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	15.7	15.7	11.8
2.506	16.6	16.6	11.8
4.264	16.6	16.6	11.8
6.021	17.0	17.0	12.0
7.779	17.0	17.0	12.0
9.536	16.8	16.8	12.0
12.000	15.9	15.9	12.0

Batch 20A[b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU
0.000	15.2	15.2
2.506	16.1	16.1
4.264	16.1	16.1
6.021	16.5	16.5
7.779	16.5	16.5
9.536	16.2	16.2
12.000	15.3	15.3

Batch 20B[b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	15.6	15.6	11.8
2.506	16.5	16.5	11.8
4.264	16.5	16.5	11.8
6.021	16.9	16.9	12.0
7.779	16.9	16.9	12.0
9.536	16.4	16.4	12.0
12.000	15.5	15.5	12.0

[a] Linear interpolation for allowable linear heat rate limits between specified burnup points and core elevation points is valid for these tables.

[b] The kW/ft limits were reduced by 0.2 kW/ft from 0 to 4.264 feet based on compliance with SER to BAW-10192-A.

Note: LHR limits provided are based on nuclear source power.

Table 2 (Continued)

Gadolinia Fuel LOCA Limits

2 wt.% Gadolinia [b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	14.9	14.9	11.4
2.506	15.7	15.7	11.4
4.264	15.7	15.7	11.4
6.021	16.1	16.1	11.6
7.779	16.1	16.1	11.6
9.536	15.9	15.9	11.6
12.000	15.1	15.1	11.6

3 wt.% Gadolinia [b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	14.2	14.2	11.1
2.506	15.0	15.0	11.1
4.264	15.0	15.0	11.1
6.021	15.4	15.4	11.3
7.779	15.4	15.4	11.3
9.536	15.2	15.2	11.3
12.000	14.4	14.4	11.3

6 wt.% Gadolinia [b]

Core Elevation (feet)	0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	13.3	13.3	10.4
2.506	14.0	14.0	10.4
4.264	14.0	14.0	10.4
6.021	14.4	14.4	10.6
7.779	14.4	14.4	10.6
9.536	14.2	14.2	10.6
12.000	13.5	13.5	10.6

[a] Linear interpolation for allowable linear heat rate limits between specified burnup points and core elevation points is valid for these tables.

[b] The kW/ft limits were reduced by 0.2 kW/ft from 0 to 4.264 feet based on compliance with SER to BAW-10192-A.

Note: LHR limits provided are based on nuclear source power.

Table 2 (Continued)

Gadolinia Fuel LOCA Limits

Core Elevation (feet)	8 wt.% Gadolinia [b] 0 MWd/mtU	34,000 MWd/mtU	62,000 MWd/mtU
0.000	13.3	13.3	10.4
2.506	14.0	14.0	10.4
4.264	14.0	14.0	10.4
6.021	14.4	14.4	10.6
7.779	14.4	14.4	10.6
9.536	14.2	14.2	10.6
12.000	13.5	13.5	10.6

[a] Linear interpolation for allowable linear heat rate limits between specified burnup points and core elevation points is valid for these tables.

[b] The kW/ft limits were reduced by 0.2 kW/ft from 0 to 4.264 feet based on compliance with SER to BAW-10192-A.

Note: LHR limits provided are based on nuclear source power.

The maximum linear heat rate for each CMS level, as measured with the FIDMS Thermal Hydraulic Package, should not be greater than the corresponding bounding value from Table 2 above. FIDMS Display 4, Thermal Limiting Condition Core Summary, shows the minimum margin to $F_Q(Z)$ limits for each axial level.

Notes: The LHR limits above are equivalent to the total peaking hot channel factor limits, $F_Q(Z)$, referred to in T.S. 3.5.2 by dividing the LHR limits by the product of the core average linear heat rate and the current fraction of rated power. The core average linear heat rate for $F_Q(Z)$ calculations is fuel batch specific and is based on nuclear source power to be consistent with the LHR limits above.

TABLE 3
LCO DNB Maximum Allowable Radial Peaking (MARP) Limits

The maximum radial peak for each fuel assembly, as measured with the Core Monitoring System (CMS) at the elevation where the assembly axial peak occurs, should not be greater than the corresponding bounding value from the table below. CMS Display 4, Thermal Limiting Condition Hot Channel Factor page, shows the minimum margin to $F^N_{\Delta H}$ limits for the fuel assemblies with the smallest (or negative) margin.

Notes: The LCO DNB Maximum Allowable Radial Peaking (MARP) limits below are equivalent to nuclear enthalpy rise hot channel factor limits, $F^N_{\Delta H}$, referred to in T.S. 3.5.2 by using the following conversion:

$F^N_{\Delta H}$ limit = (LCO DNB MARP) * [1 + 0.3 * (1 – P/P_m)]

where: P = current fraction of power and,
P_m = power adjustment factor for RC Pump combination
(1.0 for 4 pump, 0.75 for 3 pump)

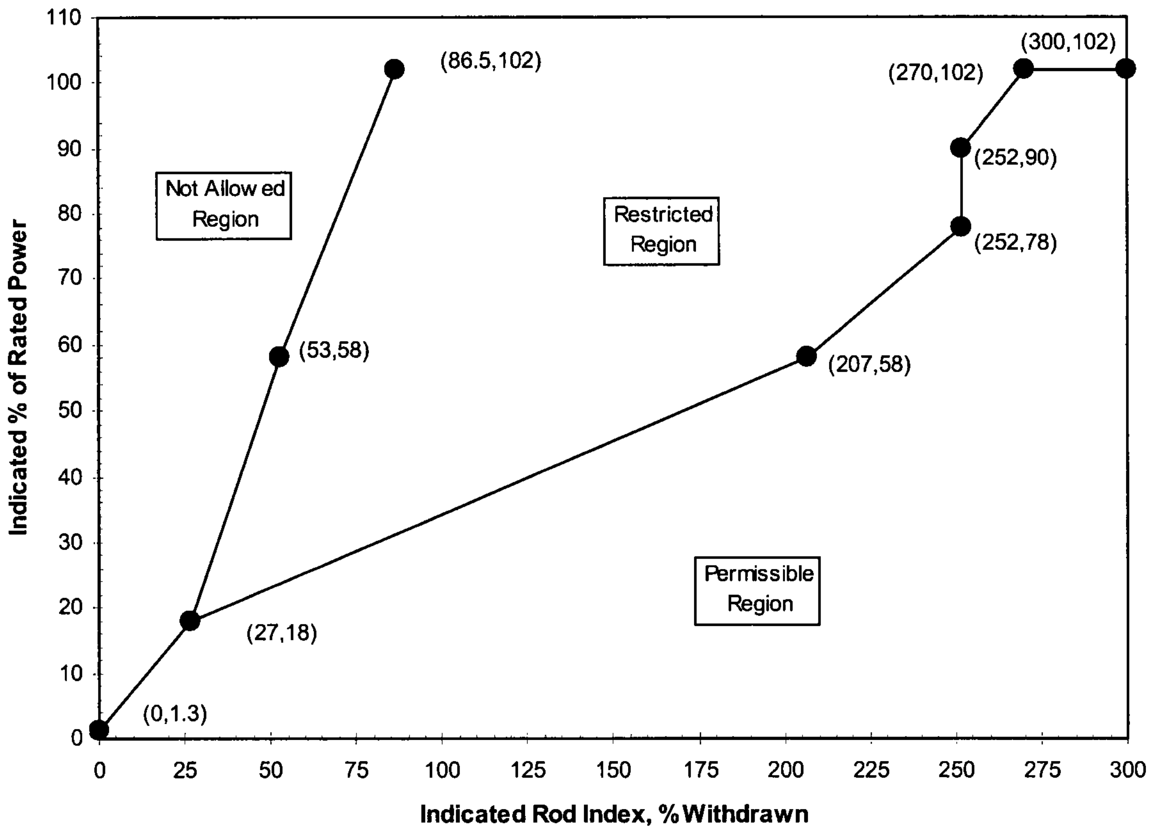
These limits are applicable to all fuel in the core for 3 and 4 RC pump operation.

These limits have been increased to reflect the 3.8% peaking uncertainty treated by Statistical Core Design (SCD) methodology.

TABLE 3 (Continued)
MARP Limits – Mark-B-HTP Assemblies

Axial Peak	x/L	Maximum Allowable Radial Peak	Axial Peak	x/L	Maximum Allowable Radial Peak
1.1	0.00	1.92810	1.5	0.00	1.97903
	0.10	1.92645		0.10	1.90417
	0.14	1.92627		0.14	1.88470
	0.20	1.92549		0.20	1.90340
	0.40	1.92402		0.40	1.96949
	0.60	1.92297		0.60	1.82753
	0.80	1.92242		0.80	1.67863
	0.88	1.90002		0.88	1.63285
	0.90	1.87983		0.90	1.63588
	1.00	1.79999		1.00	1.57121
1.2	0.00	2.00856	1.7	0.00	1.77373
	0.10	2.00502		0.10	1.68669
	0.14	2.00464		0.14	1.66357
	0.20	2.00349		0.20	1.67955
	0.40	2.00080		0.40	1.76225
	0.60	1.99931		0.60	1.69477
	0.80	1.87838		0.80	1.56172
	0.88	1.83049		0.88	1.52182
	0.90	1.81850		0.90	1.53086
	1.00	1.73949		1.00	1.46872
1.3	0.00	2.09361	1.9	0.00	1.60832
	0.10	2.08786		0.10	1.51495
	0.14	2.08745		0.14	1.48917
	0.20	2.08581		0.20	1.50272
	0.40	2.08276		0.40	1.58120
	0.60	1.97214		0.60	1.57910
	0.80	1.80957		0.80	1.46203
	0.88	1.75989		0.88	1.42598
	0.90	1.75469		0.90	1.43644
	1.00	1.68247		1.00	1.38119

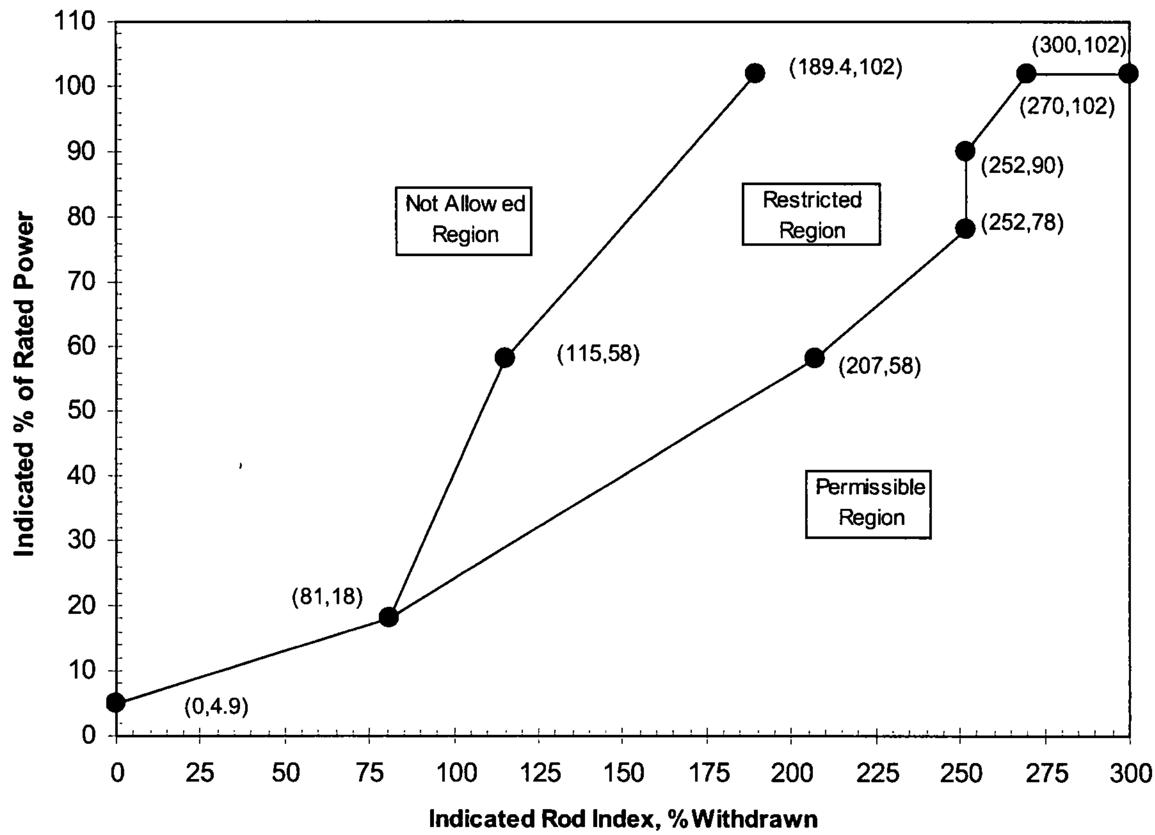
Figure 1 (Page 1 of 2)
Error Adjusted Rod Insertion Limits
(0 to 400 ±10 EFPD; 4 Pump Operation)



A Rod group overlap of 25 ±5% between sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by TS 3.5.2.5.b & 3.5.2.4.e.3

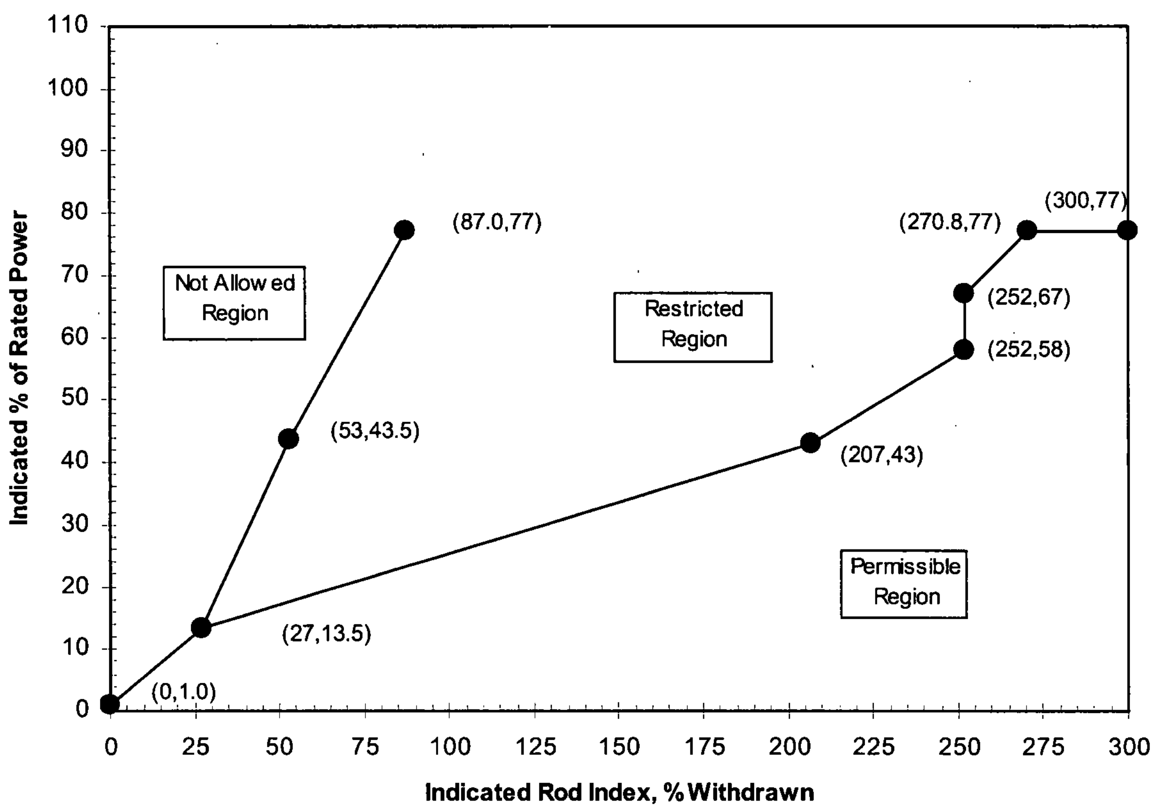
Figure 1 (Page 2 of 2)
Error Adjusted Rod Insertion Limits
(400 ±10 EFPD to EOC; 4 Pump Operation)



A Rod group overlap of 25 ±5% betw een sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by TS 3.5.2.5.b & 3.5.2.4.e.3

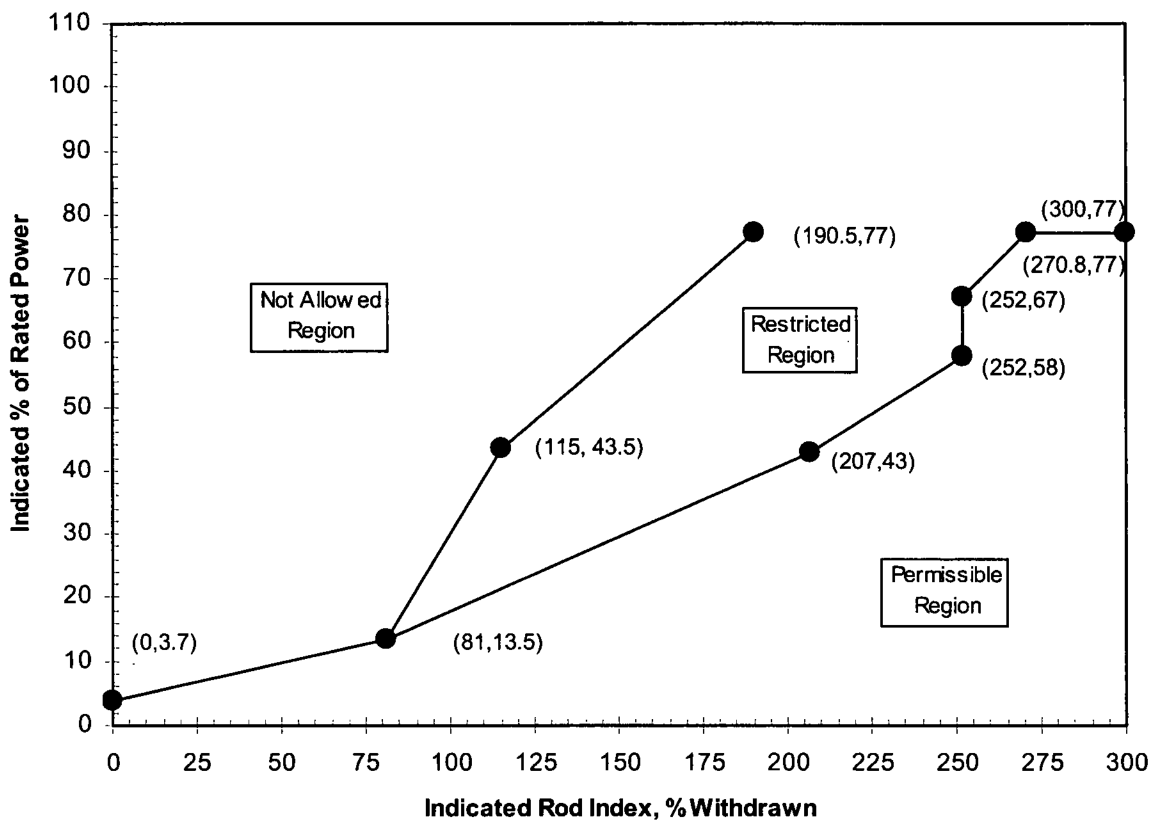
Figure 2 (Page 1 of 2)
Error Adjusted Rod Insertion Limits
(0 to 400 ±10 EFPD; 3 Pump Operation)



A Rod group overlap of 25 ±5% betw een sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by TS 3.5.2.5.b & 3.5.2.4.e.3

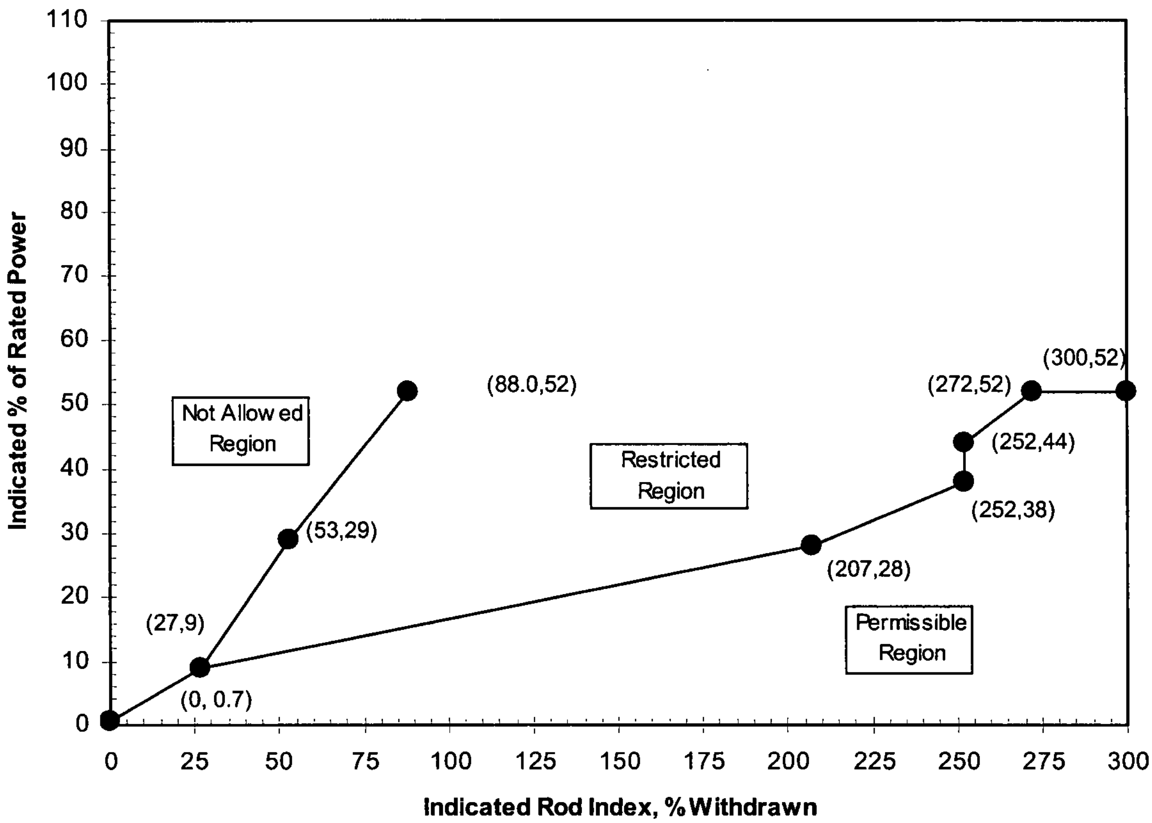
Figure 2 (Page 2 of 2)
Error Adjusted Rod Insertion Limits
(400 ±10 EFPD to EOC; 3 Pump Operation)



A Rod group overlap of 25 ±5% between sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by
TS 3.5.2.5.b & 3.5.2.4.e.3

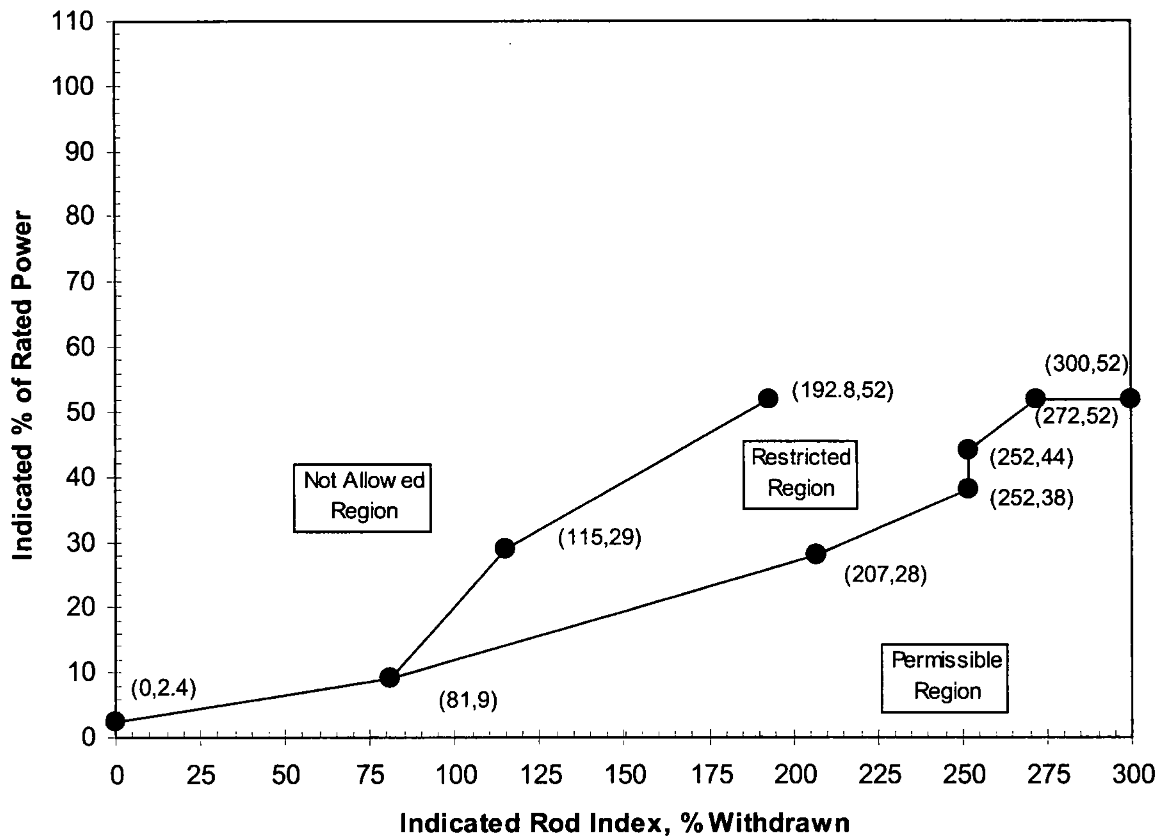
Figure 3 (Page 1 of 2)
Error Adjusted Rod Insertion Limits
(0 to 400 ±10 EFPD; 2 Pump Operation)



A Rod group overlap of 25 ±5% between sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by
TS 3.5.2.5.b & 3.5.2.4.e.3

Figure 3 (Page 2 of 2)
Error Adjusted Rod Insertion Limits
(400 ±10 EFPD to EOC; 2 Pump Operation)



A Rod group overlap of 25 $\underline{+}$5% between sequential groups 5 and 6, and 6 and 7 shall be maintained.

This figure is referred to by
TS 3.5.2.5.b & 3.5.2.4.e.3

Figure 4
Full Incore System Error Adjusted 4 Pump Imbalance Limits
(0 EFPD to EOC)

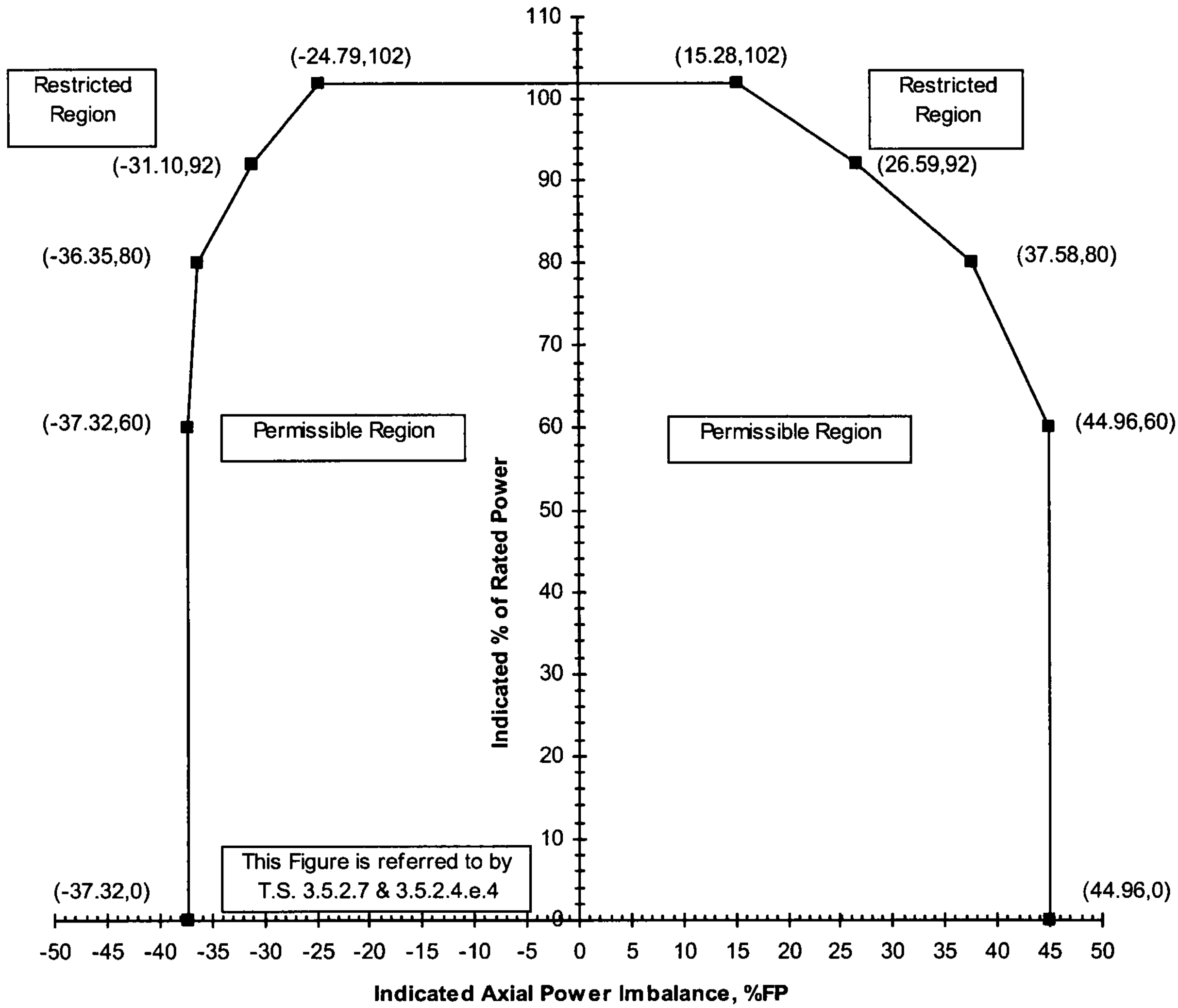


Figure 5
Full Incore System Error Adjusted 3 Pump Imbalance Limits
(0 EFPD to EOC)

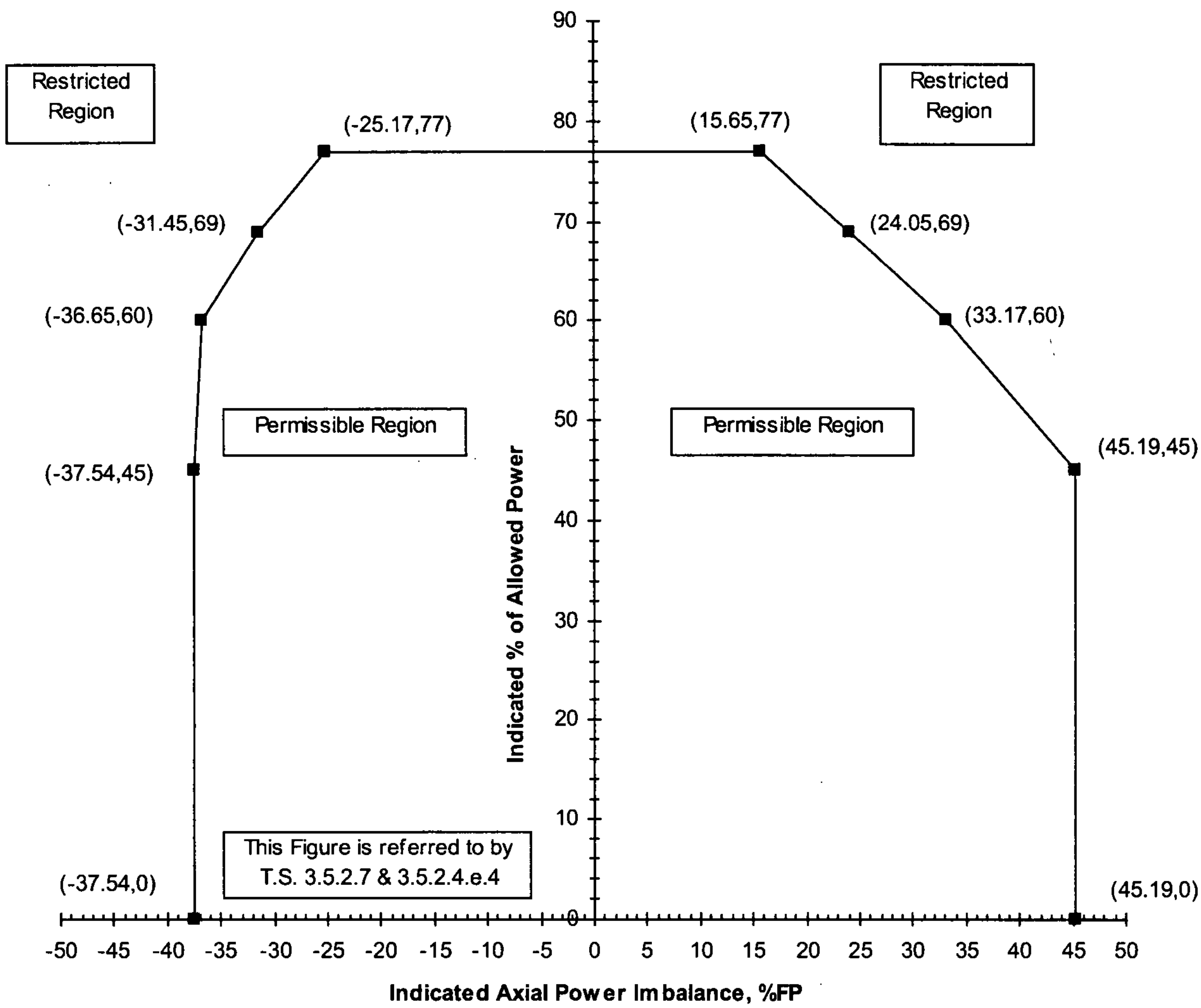


Figure 6
Full Incore System Error Adjusted 2 Pump Imbalance Limits
(0 EFPD to EOC)

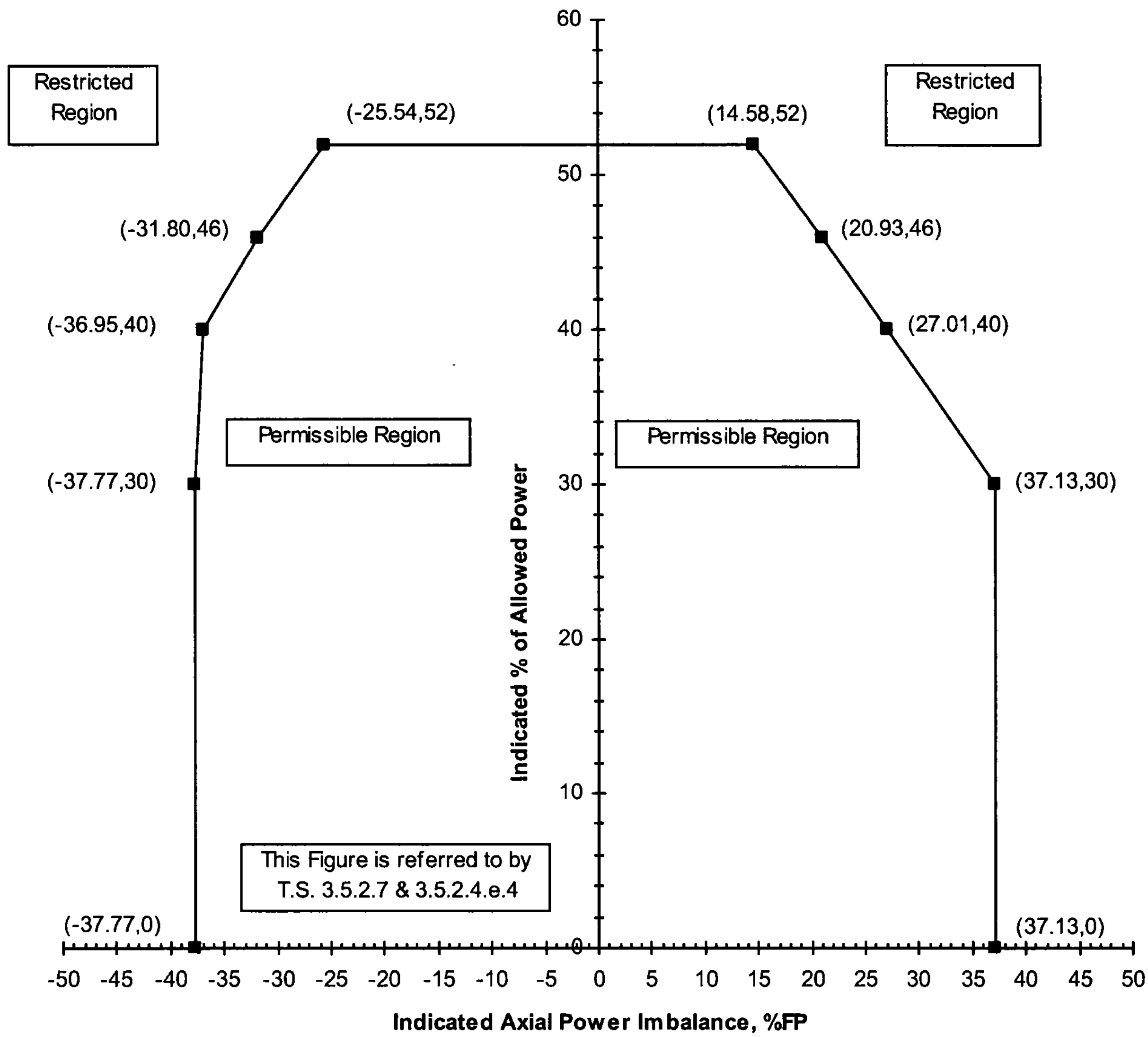
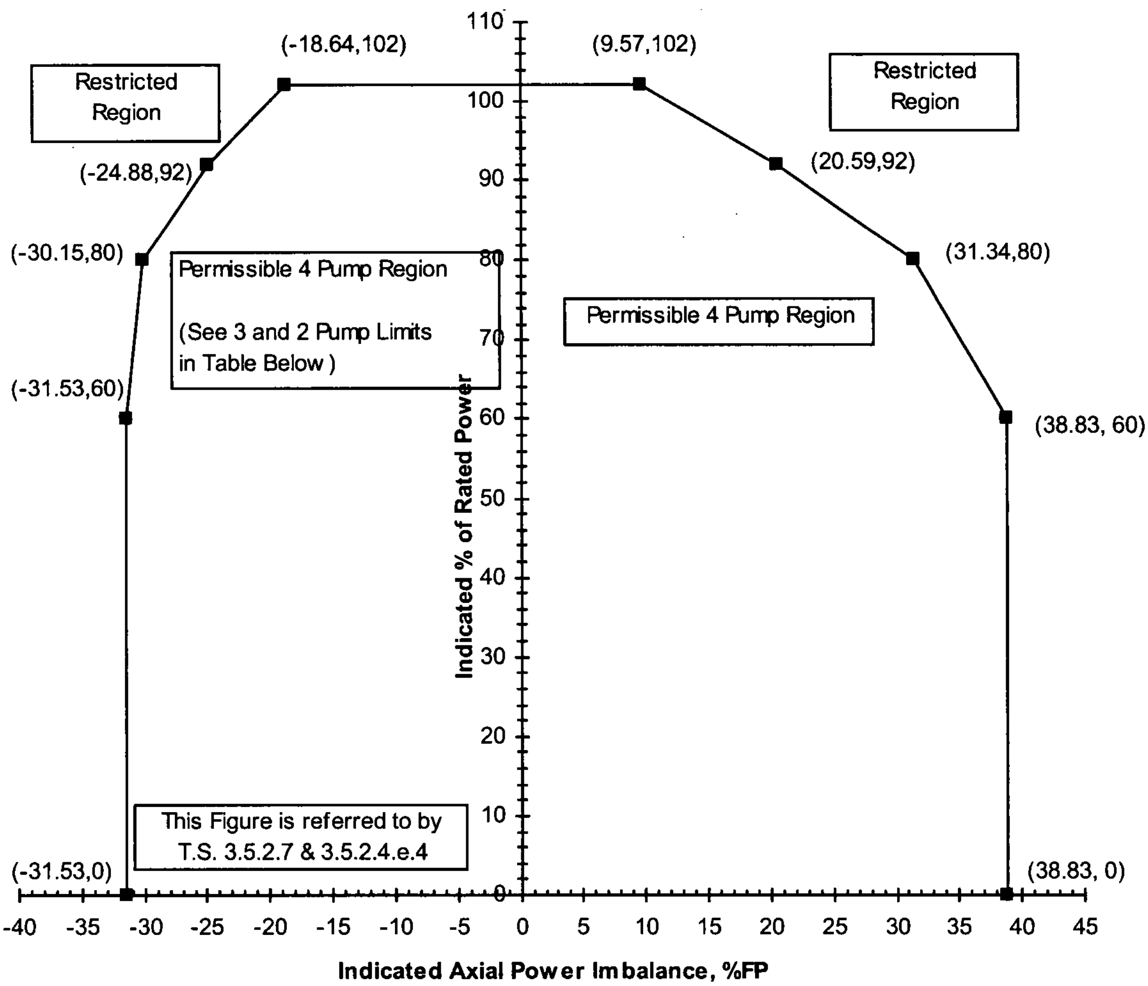


Figure 7
Out-of-Core Detector System Error Adjusted Imbalance Limits
(0 EFPD to EOC)

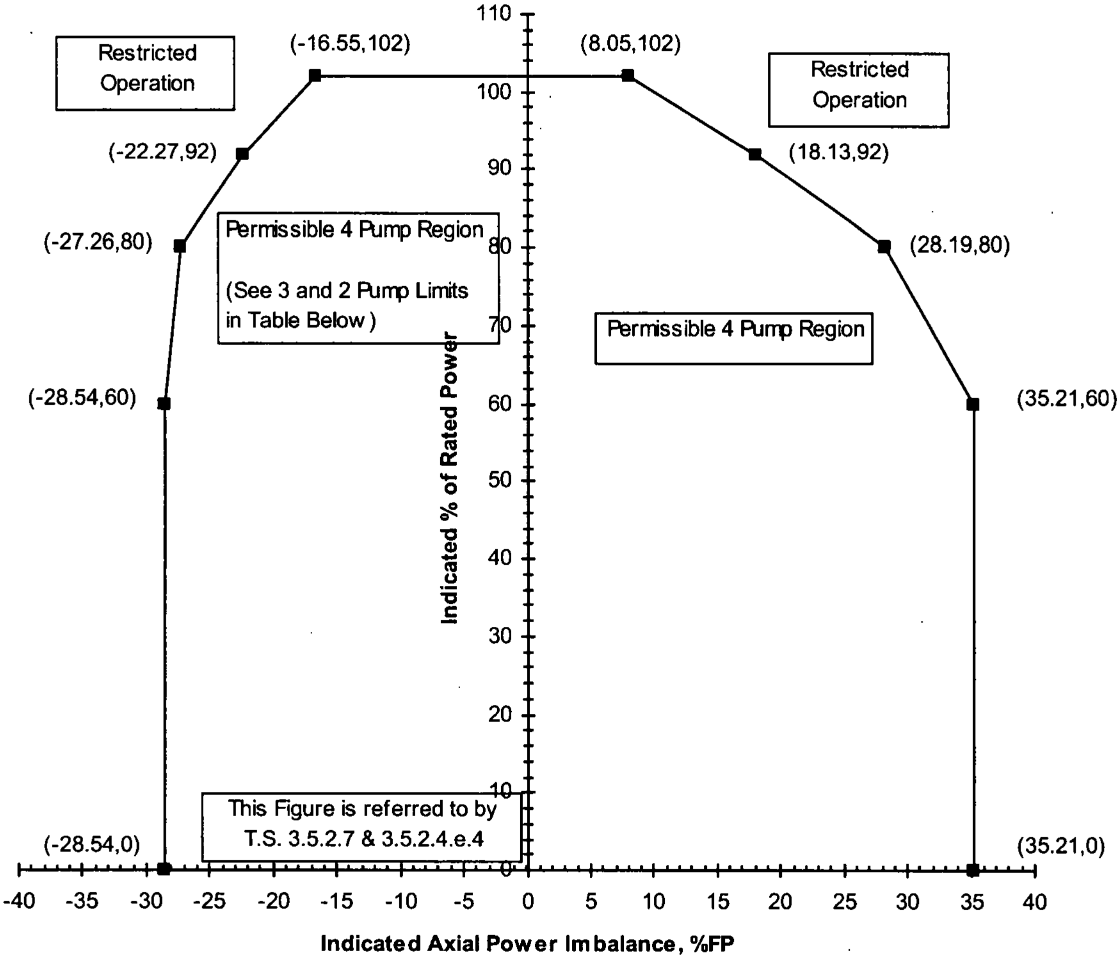


Out-of-Core Detector System Error Adjusted Imbalance Limits (0 EFPD to EOC)
for 3 and 2 Pump Operation

Power (%FP)	Neg. Imb. (%FP)	Pos. Imb. (%FP)
	3 Pump Operation	
77	-19.56	10.47
69	-25.73	18.66
60	-30.89	27.57
45	-32.07	39.38
0	-32.07	39.38

Power (%FP)	Neg. Imb. (%FP)	Pos. Imb. (%FP)
	2 Pump Operation	
52	-20.46	9.95
46	-26.56	16.15
40	-31.62	22.10
30	-32.61	31.99
0	-32.61	31.99

Figure 8
Minimum Incore System Error Adjusted Imbalance Limits (0 EFPD to EOC)



Minimum Incore System Error Adjusted Imbalance Limits (0 EFPD to EOC)
for 3 and 2 Pump Operation

Power (%FP)	Neg. Imb. (%FP)	Pos. Imb. (%FP)
	3 Pump Operation	
77	-17.42	9.12
69	-23.08	16.62
60	-27.81	24.77
45	-29.06	35.58
0	-29.06	35.58

Power (%FP)	Neg. Imb. (%FP)	Pos. Imb. (%FP)
	2 Pump Operation	
52	-18.30	8.74
46	-23.88	14.40
40	-28.51	19.84
30	-29.59	28.89
0	-29.59	28.89

NOTE: These limits are based on the condition that no individual long emitter detector affecting the minimum in-core system imbalance calculation exceeds 73% sensitivity depletion. If 73% depletion sensitivity is exceeded, these limits must all be reduced by 2.8%FP imbalance.

Figure 9 (Page 1 of 4)
LOCA Limited Maximum Allowable Linear Heat Rates for UO2 Fuel Rods
Mark-B-HTP Fuel Assemblies, Except Batches 20A and 20B

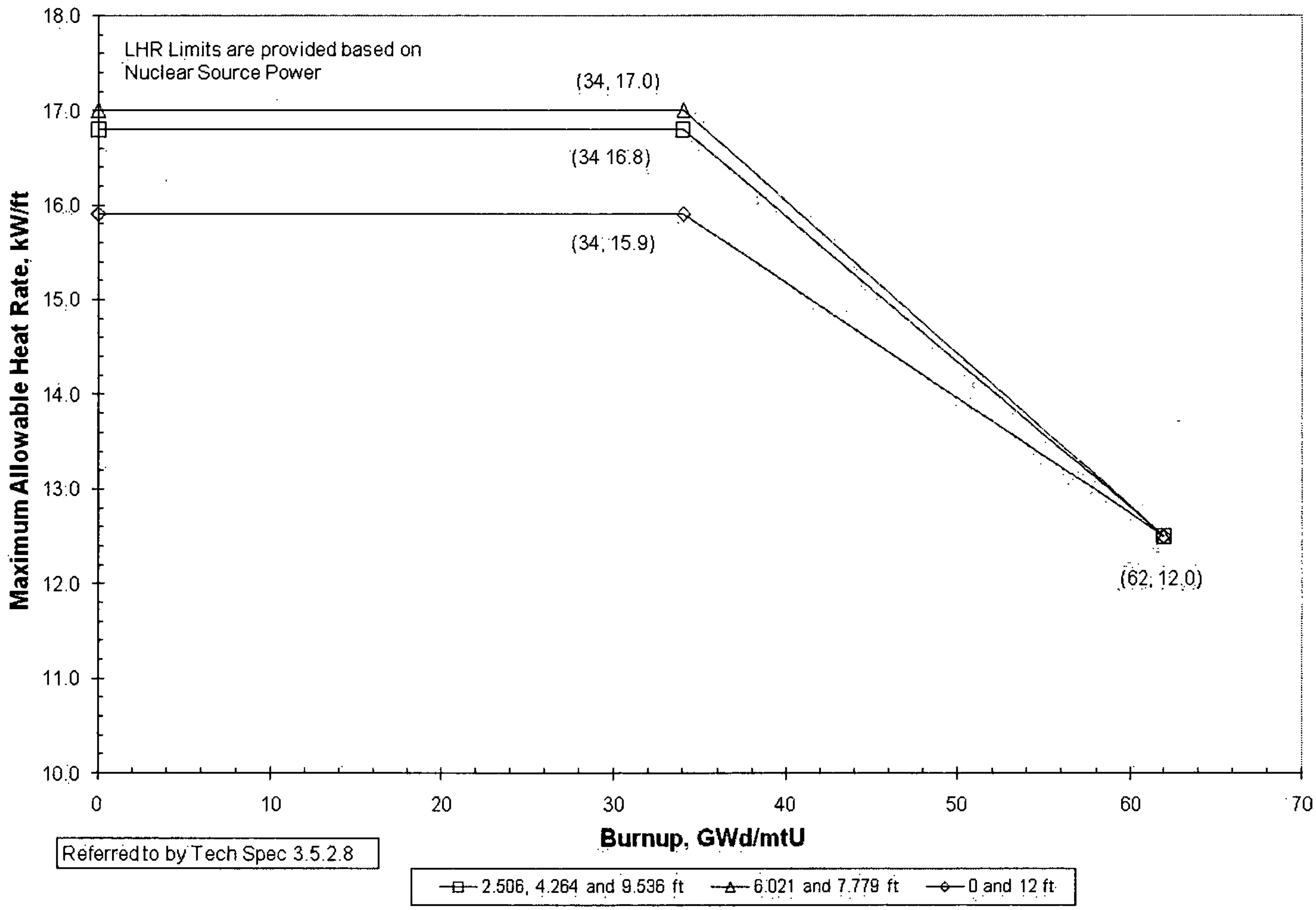
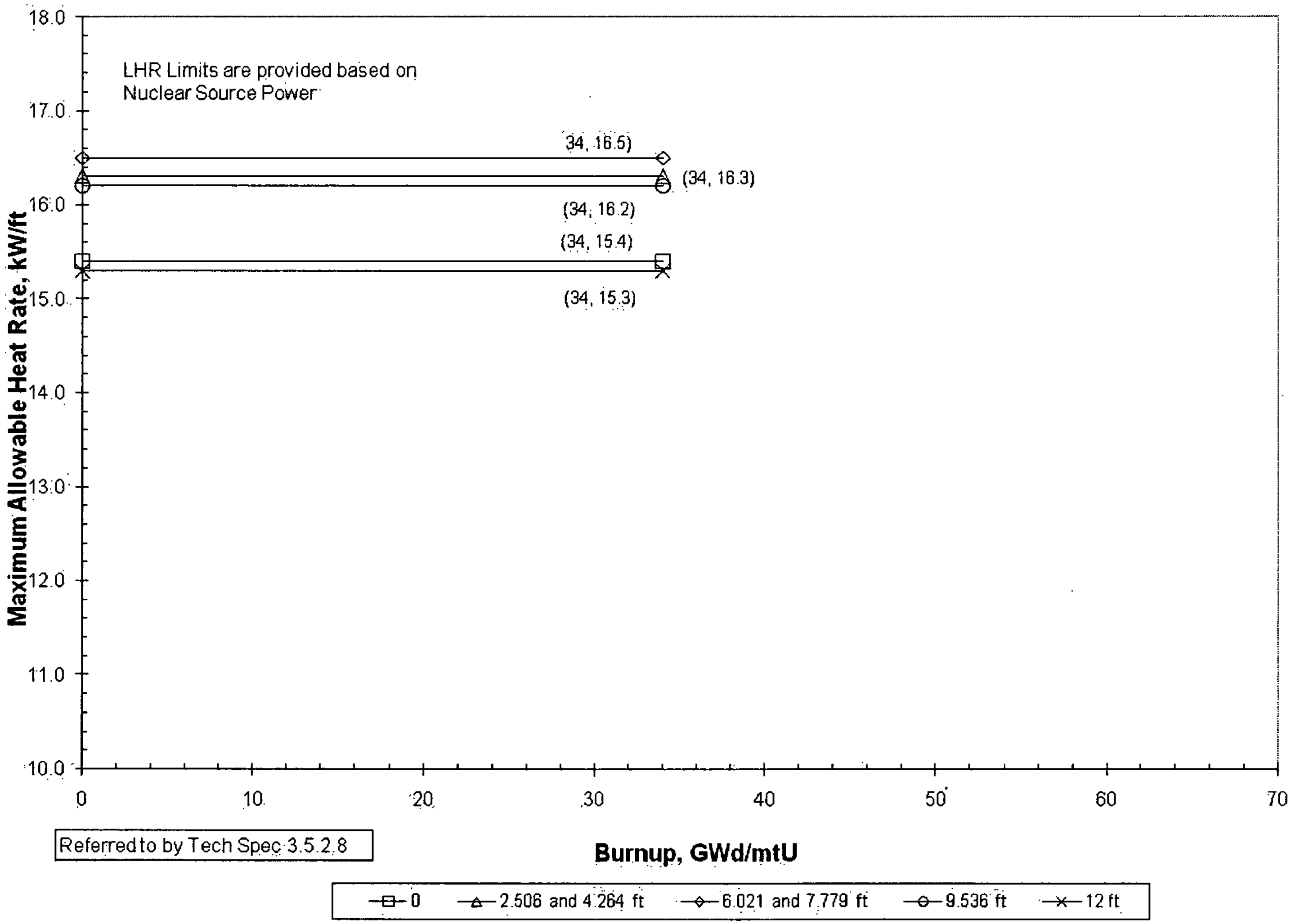


Figure 9 (Page 2 of 4)
LOCA Limited Maximum Allowable Linear Heat Rates for UO2 Fuel Rods
Mark-B-HTP Fuel Assemblies, Batch 20A



Referred to by Tech Spec 3.5.2.8

Figure 9 (Page 3 of 4)
LOCA Limited Maximum Allowable Linear Heat Rates for UO2 Fuel Rods
Mark-B-HTP Fuel Assemblies, Batch 20B

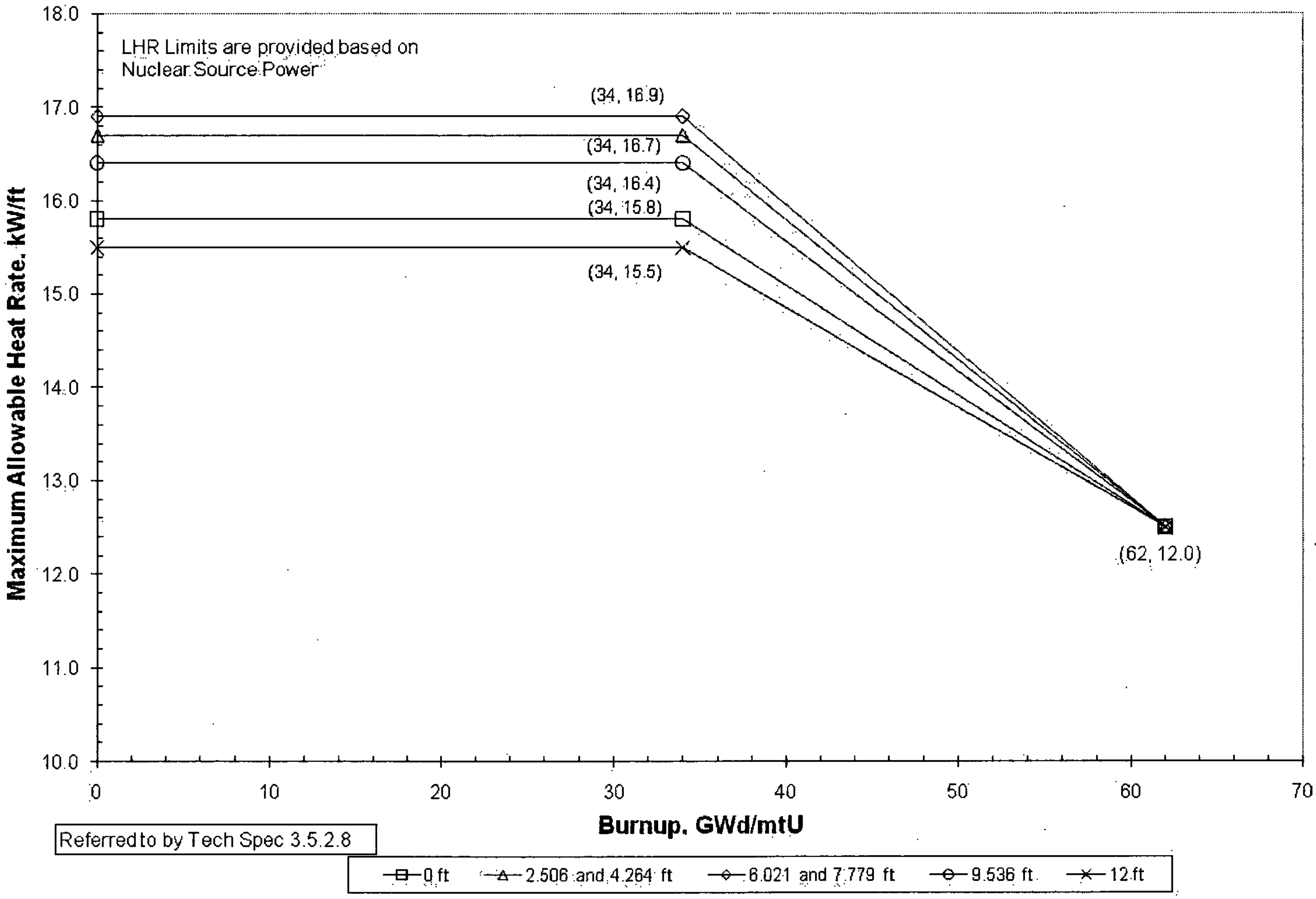


Figure 9 (Page 4 of 4)
MTC Limit vs. Power Level

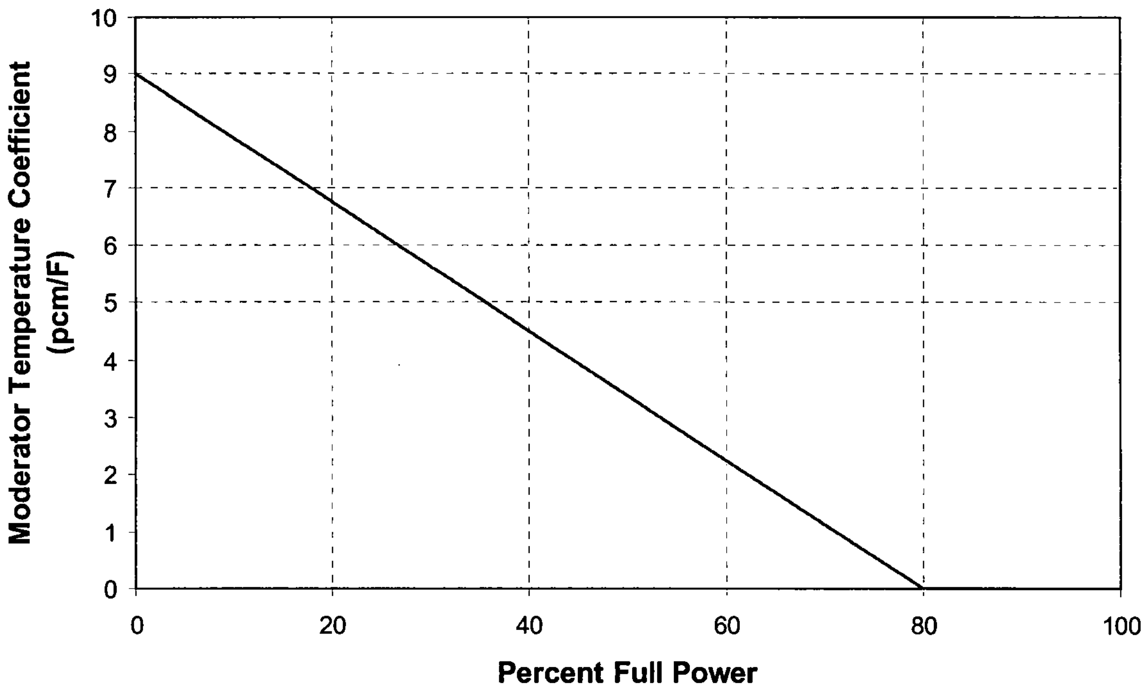
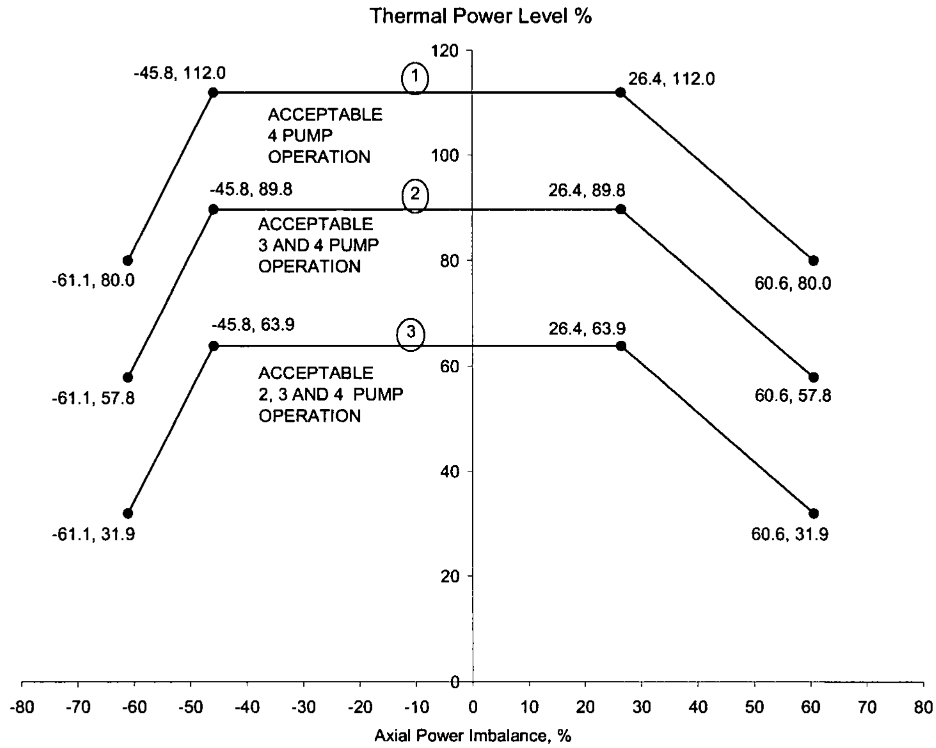
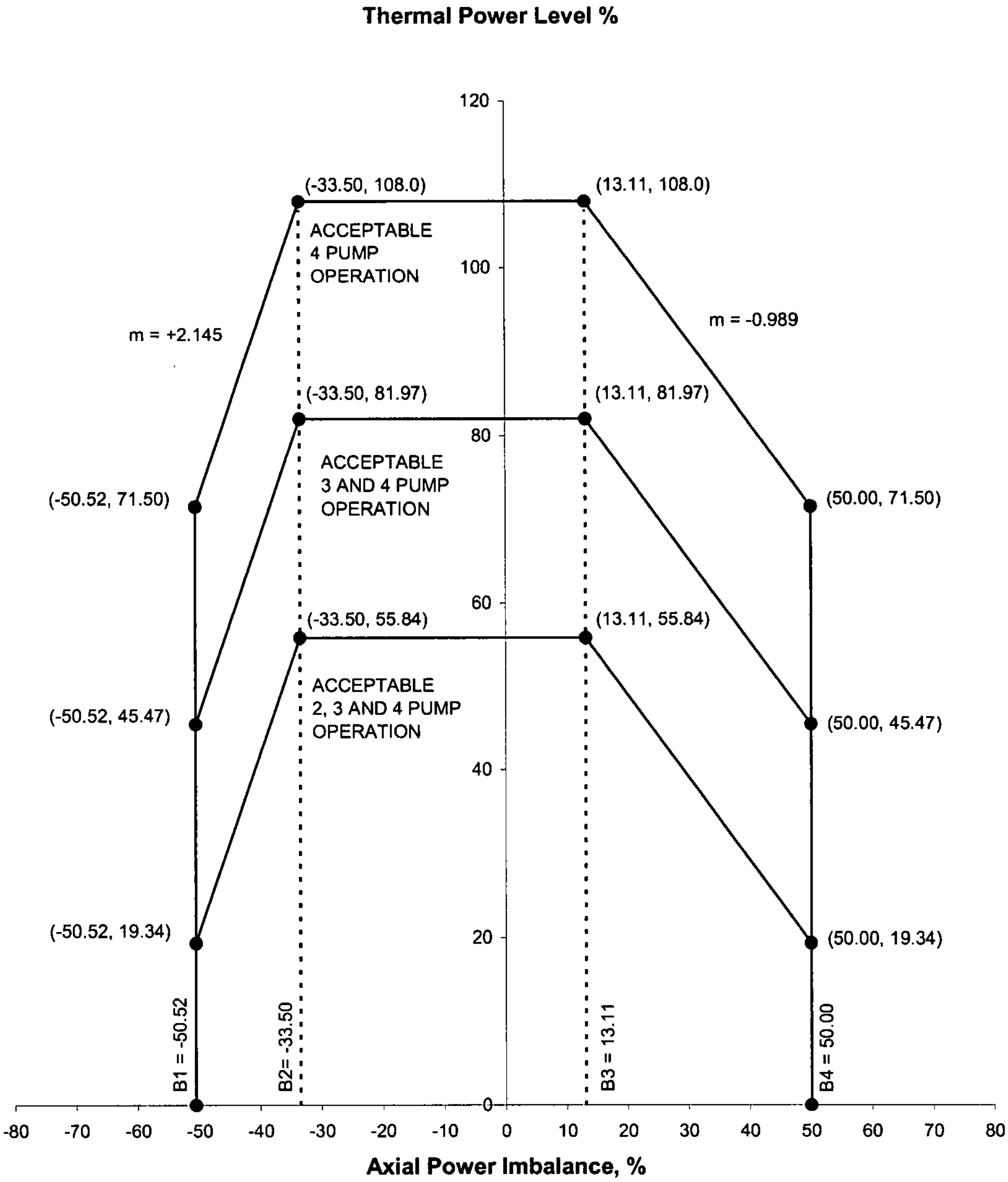


Figure 10
Axial Power Imbalance Protective Limits



CURVE	EXPECTED MINIMUM REACTOR COOLANT FLOW (lb/hr)
1	137.77×10^6
2	103.22×10^6
3	67.90×10^6

Figure 11
Reactor Protection System Maximum Allowable Setpoints for Axial Power Imbalance



REFERENCES:

1. BAW-10179P-A, Rev. 8, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses," May 2010.

2. FRA-ANP Doc. No 86-1172640-00, "Detector Lifetime Extension Final Report for TMI-1," October 1989.

3. ANP-3023, Rev. 0, "Three Mile Island Unit 1 Cycle 19 Reload Report," September 2011.

Enclosure 1

Operating Limits Not Required by Technical Specifications

1. Maximum Allowable Local Linear Heat Rate Limits

(Reference: T.S. 2.1 Bases)

The maximum allowable local linear heat rate limit is the minimum LHR that will cause centerline fuel melt in the rod or cause the fuel rod cladding to exceed the 1.0% transient strain limit. These limits are the basis for the imbalance portions of the Axial Power Imbalance Protective Limits and Setpoints in Figures 10 and 11 of the COLR, respectively. The limits are fuel design-specific; the value for the most limiting fuel design in the current core is used for monitoring as given below:

- AREVA Mark-B-HTP / Mark-B-HTP-1

Burnup (MWd/mtU)	Linear Heat Rate to Melt (LHRTM) (kW/ft)	Linear Heat Rate to 1% Transient Strain (kW/ft)
0	25.15	23.99
50	25.15	
1000	25.35	
10000	25.24	
15000	24.54	
20000	24.09	23.99
25000	23.60	
30000	23.13	22.80
40000	22.17	21.92
50000	20.99	20.57
60000		18.65
62000	19.58	18.41

2. Alternate Minimum Boron Requirements for Cold Shutdown

(References: T.S. 3.3.1.1.a, T.S. 3.3. Bases, FSAR 9.2.1.2)

The Borated Water Storage Tank (BWST) is required by Technical Specifications 3.3.1.1.a to be available as a source of borated water to meet ECCS LOCA criteria. The T.S. 3.3.1.1.a requirements also ensure that there is a sufficient source of borated water available to bring the reactor to cold shutdown under normal operating conditions. Although not required by T.S., other sources of borated water can be used in lieu of the BWST for the purpose of achieving cold shutdown under normal operating conditions.

The alternate source of borated water shall contain the equivalent of at least 740 ft^3 of 12,500 ppm boron. There is no T.S. requirement to maintain an alternate source tank at this level, however out-of-service time for this tank should be minimized. The design bases for this tank are described in FSAR Section 9.2.1.2. The Boric Acid Mix Tank (BAMT) or one of the Reclaimed Boric Acid Tanks (RBAT) can be used as the alternate source of borated water.

Enclosure 2

DNBR-Related Bases Descriptions

1. Power-to-Flow Trip Setpoints

The nuclear overpower trip setpoint based on RCS flow (power/flow or flux/flow trip) for the current cycle is 1.08. This setpoint applies to four-, three- and two-pump operation as described in T.S. Table 2.3-1 and Figure 11 of the COLR.

The power/flow trip, in combination with the axial power imbalance trip, provides steady-state DNB protection for the Axial Power Imbalance Protective Limit (Figure 10). A reactor trip is initiated when the core power, axial power peaking and reactor coolant flow conditions indicate an approach to the DNBR limit. The power/flow trip also provides transient protection for loss of reactor coolant flow events, such as loss of one RC pump from a four RC pump operating condition and a locked rotor accident.

Power level and reactor flow rate combinations for four-, three- and two-pump operating conditions are as follows:

1. Trip would occur when four reactor coolant pumps are operating if power level is 108 percent and flow rate is 100 percent, or power level is 100 percent and flow rate is 92.5 percent.

2. Trip would occur when three reactor coolant pumps are operating if power level is 81.97 percent and flow rate is 75.9 percent or power level is 75 percent and flow rate is 69.4 percent.

3. Trip would occur when one reactor coolant pump is operating in each loop (total of two pumps operating) if power level is 55.84 percent and flow rate is 51.7 percent or power level is 49 percent and flow rate is 45.4 percent.

The power level trip and associated reactor power/axial power imbalance boundaries are reduced by the power-to-flow ratio as a percent (1.08 percent) for each one percent flow reduction.

2. Design Nuclear Power Peaking Factors

(Reference: T.S. 2.1 Bases)

The design nuclear power peaking factors given below define the reference design peaking condition in the core for operation at the maximum overpower. These peaking factors serve as the basis for the pressure/temperature core protection safety limits and the power-to-flow limit that prevent cladding failure due to DNB overheating.

- Nuclear Enthalpy Rise Hot Channel Factor (Radial-Local Peaking Factor), $F^N_{\Delta H}$

  $F^N_{\Delta H}$ = 1.80

- Axial Flux Shape Peaking Factor, F^N_Z

  F^N_Z = 1.65 (cosine with tails)

- Total Nuclear Power Peaking Factor, F^N_Q

  $F^N_Q = F^N_{\Delta H} \times F^N_Z$

  F^N_Q = 2.97