Core Operating Limits Report

For

Quad Cities Unit 1 Cycle 27

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Record of Quad Cities 1 Cycle 27 COLR Revisions

Revision	Description
16	Incorporates MCPR penalties due to Issue Report 04410817
15	Initial issuance for Q1C27

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1. Terms and Definitions

AOO	Anticipated operational occurrence
ASD	Adjustable Speed Drive
BOC	Beginning of cycle
CAVEX	Core average exposure
CPR	Critical power ratio
CRWE	Control rod withdrawal error
EFPD	Effective full power day
EFPH	Effective full power hour
EOCLB	End of cycle licensing basis
EOFPL	End of full power life
EOFPLB	End of full power licensing basis
EOOS	Equipment out of service
FHOOS	Feedwater heater out of service
FWT	Feedwater temperature
FRV	Feedwater Regulating Valve
ICF	Increased core flow
Interior Fuel Bundles	Fuel bundles located on the interior of the core indicated by the letter C in the core map of Reference 10
ISS	Intermediate scram speed
kW/ft	KiloWatts per foot
LHGR	Linear heat generation rate
$LHGRFAC_f$	Flow dependent LHGR multiplier
$LHGRFAC_p$	Power dependent LHGR multiplier
LPRM	Local power range monitor
MAPLHGR	Maximum average planar linear heat generation rate
MANFRV1	Manual feedwater regulating valve scenario 1 (1 FRV in manual mode and the position is no more than 3% further open than the position of the FRV in automatic mode)
MANFRV2	Manual feedwater regulating valve scenario 2 (1 FRV in manual mode and the position is greater than 3% further open than the position of the FRV in automatic mode)
MCPR	Minimum critical power ratio
$MCPR_f$	Flow dependent MCPR
$MCPR_p$	Power dependent MCPR
MELLLA	Maximum extended load line limit analysis
MSIVOOS	Main steam isolation valve out of service
MWd/MTU	MegaWatt days per metric ton Uranium
NRC	Nuclear Regulatory Commission
NSS	Nominal scram speed
OLMCPR	Operating limit minimum critical power ratio
OOS	Out of service
OPRM	Oscillation power range monitor
PBDA	Period based detection algorithm
P_{bypass}	Power below which direct scram on TSV/TCV closure is bypassed
PCOOS	Pressure controller out of service
Peripheral Fuel Bundles	Fuel bundles located on the outer ring of the core indicated by the letter P in the core map of Reference 10
PLUOOS	Power load unbalance out of service
SLMCPR	Safety limit minimum critical power ratio
SLO	Single loop operation
SRVOOS	Safety relief valve out of service
TBV	Turbine bypass valve
TBVOOS	Turbine bypass valves out of service
TCV	Turbine control valve
TCV SLOW C	TCV slow closure
TIP	Traversing incore probe
TLO	Two loop operation
TMOL	Thermal mechanical operating limit

TRM	Technical Requirements Manual
TSSS	Technical Specification scram speed
TSV	Turbine stop valve

2. General Information

This report is prepared in accordance with Technical Specification 5.6.5. The Quad Cities Unit 1 Cycle 27 (Q1C27) reload is licensed by Framatome.

Licensed rated thermal power is 2957 MWth. Rated core flow is 98 Mlb/hr. Operation up to 108% rated core flow is licensed for this cycle. For allowed operating regions, see applicable power/flow map.

The licensing analysis supports full power operation to EOCLB (38,023 MWd/MTU CAVEX). Note that this value includes coastdown, where full power operation is not expected. The transient analysis limits are provided for operation up to specific CAVEX exposures as defined in Section 4.3.

Coastdown is defined as operation beyond EOFPL with the plant power gradually reducing as available core reactivity diminishes. The Q1C27 reload analyses do not credit this reduced power during coastdown and the EOCLB limits remain valid for operation up to rated power.

Power and flow dependent limits are listed for various power and flow levels. Linear interpolation on power and flow (as applicable) is to be used to find intermediate values. Linear interpolation is also to be used for table items intentionally left blank, as indicated by boxes which are grayed out.

$MCPR_p$ varies with scram speed. All other thermal limits are analyzed to remain valid with NSS, ISS, and TSSS.

$LHGRFAC_f$ is independent of feedwater temperature and EOOS conditions.

For thermal limit monitoring above 100% rated power or 108% rated core flow, the 100% rated power and the 108% core flow thermal limit values, respectively, shall be used. Steady state operation is not allowed in this region. Limits are provided for transient conditions only.

3. Average Planar Linear Heat Generation Rate

Technical Specification Sections 3.2.1 and 3.4.1

Table 3-1 provides the MAPLHGR SLO multipliers for ATRIUM 10XM fuel.

For ATRIUM 10XM fuel, the lattice-specific MAPLHGR limits for TLO can be found in Tables 3-2 and 3-3.

During SLO, the limits in Tables 3-2 and 3-3 are multiplied by the SLO multiplier listed in Table 3-1.

Table 3-1: MAPLHGR SLO Multipliers
(References 2 and 7)

Fuel Type	Multiplier
ATRIUM 10XM	0.80

Table 3-2: MAPLHGR for ATRIUM 10XM – All but Special Lattices
(References 2 and 7)

Lattices **All Cycle 25 Lattices** **Cycle 26 Lattices:** **XMLCP-0720L-0G0a, XMLCB-0720L-0G0a, XMLCB-4538L-17GV80A, XMLCB-4538L-17GV80, XMLCB-4538L-17G80, XMLCB-4561L-16GV80, XMLCB-4556L-17G80, XMLCB-4642L-13G80, XMLCT-0720L-0G0da, XMLCT-0720L-0G0a, XMLCT-4602L-16GV65A, XMLCT-4602L-16GV65, XMLCT-4721L-12G65** **Cycle 27 Lattices:** **XMLCP-0720L-0G0a, XMLCB-0720L-0G0a, XMLCB-4430L-16G80, XMLCB-4425L-14GV80, XMLCB-4638L-12G80, XMLCTP-4386L-16G80, XMLCT-4386L-16G80, XMLCT-4401L-14G80, XMLCT-4401L-14G60, XMLCT-4680L-13G60, XMLCT-0720L-0G0a, XMLCT-0720L-0G0a-MOD**	
Avg. Planar Exposure (MWd/MTU)	**TLO MAPLHGR (kW/ft)**
0	12.20
20,000	12.20
67,000	7.30

Table 3-3: MAPLHGR for ATRIUM 10XM – Special Lattices
(References 2 and 7)

Lattices **Cycle 26 Lattices:** **XMLCTP-4596L-17G80, XMLCT-4596L-17G80, XMLCTP-4715L-13G80, XMLCT-4715L-13G80** **Cycle 27 Lattices:** **XMLCTP-4458L-14G80, XMLCT-4458L-14G80, XMLCT-4458L-14G60, XMLCTP-4681L-13G80, XMLCT-4681L-13G80**	
Avg. Planar Exposure (MWd/MTU)	**TLO MAPLHGR (kW/ft)**
0	12.20
15,000	12.20
67,000	7.30

4. Operating Limit Minimum Critical Power Ratio

Technical Specification Sections 3.2.2, 3.4.1, and 3.7.7

The OLMCPRs for Q1C27 are established so that less than 0.1% of the fuel rods in the core are expected to experience boiling transition during an AOO initiated from rated or off-rated conditions and support current Technical Specifications SLMCPR values (Reference 2).

Tables 4-3, 4-5, 4-7, 4-9, 4-11, 4-13, 4-15, 4-17, 4-19, and 4-21 include MCPR limits for the interior fuel bundles for various specified EOOS conditions. Tables 4-4, 4-6, 4-8, 4-10, 4-12, 4-14, 4-16, 4-18, 4-20, and 4-22 include administrative MCPR values for peripheral fuel bundles for various specified EOOS conditions. The administrative MCPR values are determined by the cycle-specific analyses contained in References 2 and 9. The EOOS conditions separated by "/" in these tables represent single EOOS conditions and not any combination of conditions. Refer to Section 8 for a detailed explanation of allowable EOOS conditions.

The administrative MCPRp and MCPRf values generated in the tables identified above were calculated using the bounding administrative MFLCPR value found in Table 9 of Reference 9 for all power and flow conditions.

4.1. Manual Flow Control MCPR Limits

The OLMCPR is determined for a given power and flow condition by evaluating the power-dependent MCPR and the flow-dependent MCPR and selecting the greater of the two.

4.1.1. Power-Dependent MCPR

The OLMCPR as a function of core thermal power ($MCPR_p$) is shown in Tables 4-3 through 4-20. $MCPR_p$ limits are dependent on scram times as described in Section 4.2, exposure as described in Section 4.3, FWT, fuel bundle core location, and whether the plant is in TLO or SLO. TLO limits and administrative values for ATRIUM 10XM fuel are given in Tables 4-3 through 4-14 and SLO limits and administrative values for ATRIUM 10XM fuel are given in Tables 4-15 through 4-20.

4.1.2. Flow-Dependent MCPR

Table 4-21 gives the OLMCPR limit as a function of the flow ($MCPR_f$) for interior fuel bundles based on the applicable plant condition for ATRIUM 10XM fuel. Table 4-22 gives the OLMCPR administrative values as a function of the flow ($MCPR_f$) for peripheral fuel bundles based on the applicable plant condition for ATRIUM 10XM fuel.

4.2. Scram Time

TSSS, ISS, and NSS refer to scram speeds. The scram time values associated with these speeds are shown in Table 4-1. The TSSS scram times shown in Table 4-1 are the same as those specified in the Technical Specifications (Reference 4).

To utilize the OLMCPR limits and administrative values for NSS in Tables 4-3, 4-4, 4-9, 4-10, 4-15, and 4-16, the average control rod insertion time at each control rod insertion fraction must be equal to or less than the NSS time shown in Table 4-1 below.

To utilize the OLMCPR limits and administrative values for ISS in Tables 4-5, 4-6, 4-11, 4-12, 4-17 and 4-18, the average control rod insertion time at each control rod insertion fraction must be equal to or less than the ISS time shown in Table 4-1 below.

The “Average Control Rod Insertion Time” is defined as the sum of the control rod insertion times of all operable control rods divided by the number of operable control rods. Conservative adjustments to the NSS and ISS scram speeds were made to the analysis inputs to appropriately account for the effects of 1 stuck control rod and one additional control rod that is assumed to fail to scram (Reference 2).

To utilize the OLMCPR limits and administrative values for TSSS in Tables 4-7, 4-8, 4-13, 4-14, 4-19 and 4-20, the control rod insertion time of each operable control rod at each control rod insertion fraction must be less than or equal to the TSSS time shown in Table 4-1. The Technical Specifications allow operation with up to 12 “slow” and 1 stuck control rod. One additional control rod is assumed to fail to scram for the system transient analyses performed to establish $MCPR_p$ limits (Reference 2). Conservative adjustments to the TSSS scram speeds were made to the analysis inputs to appropriately account for the effects of the slow and stuck rods on scram reactivity (Reference 2).

For cases below 38.5% power (P_{bypass}), the results are relatively insensitive to scram speed, and only TSSS analyses were performed (Reference 2).

Table 4-1: Scram Times
(References 2 and 4)

Control Rod Insertion Fraction (%)	NSS (seconds)	ISS (seconds)	TSSS (seconds)
5	0.324	0.360	0.48
20	0.694	0.720	0.89
50	1.510	1.580	1.98
90	2.670	2.800	3.44

4.3. Exposure Dependent MCPR Limits

Exposure-dependent $MCPR_p$ limits and administrative values were established to support operation for the entire cycle duration. Note that the thermal limits and administrative values are based on CAVEX. The CAVEX values at which point the $MCPR_p$ limits and administrative values are required to be changed are shown in Table 4-2 below. The limits and administrative values at a later exposure range can be used earlier in the cycle as they are the same or more conservative.

Table 4-2: Exposure Basis for Transient Analysis
(Reference 2)

Core Average Exposure (MWd/MTU)	Description
37,346	Design basis rod patterns to EOFPL + 25 EFPD (EOFPLB)
38,023	EOCLB – Maximum licensing core exposure, including coastdown

4.4. Recirculation Pump ASD Settings

Technical Requirement Manual 2.1.a.1

Quad Cities 1 Cycle 27 was analyzed with a slow flow excursion event assuming a failure of the recirculation flow control system such that the core flow increases slowly to the maximum flow physically permitted by the equipment, assumed to be 112% of rated core flow (Reference 2); therefore the recirculation pump ASD must be set to maintain core flow less than 112% (109.76 Mlb/hr) for all runout events.

Table 4-3: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for NSS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	1.93		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	1.95		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.43
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.24	2.24	1.72	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.08		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.08		1.43
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.24	1.72	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-4: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_P$ Administrative Values for NSS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.68		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	5.74		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.21
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.60	6.60	5.07	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.13		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.13		4.21
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.60	5.07	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-5: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for ISS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	1.95		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	1.95		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.43
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.25	2.25	1.72	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.09		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.09		1.43
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.25	1.72	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-6: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_p$ Administrative Values for ISS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.74		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	5.74		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.21
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.63	6.63	5.07	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.16		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.16		4.21
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.63	5.07	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-7: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for TSSS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	2.02		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	2.04		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.46
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.26	2.26	1.76	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.17		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.18		1.44
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.26	1.76	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-8: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_p$ Administrative Values for TSSS Insertion Times, BOC to EOFPLB (37,346 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.95		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	6.01		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.30
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.66	6.66	5.18	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.39		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.42		4.24
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.66	5.18	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-9: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for NSS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	1.93		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	1.95		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.43
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.24	2.24	1.72	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.08		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.08		1.43
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.24	1.72	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-10: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_p$ Administrative Values for NSS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.68		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	5.74		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.21
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.60	6.60	5.07	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.13		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.13		4.21
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.60	5.07	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-11: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for ISS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	1.95		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	1.95		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.43
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.25	2.25	1.72	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.09		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.09		1.43
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.25	1.72	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-12: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_p$ Administrative Values for ISS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.74		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	5.74		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.21
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.63	6.63	5.07	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.16		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.16		4.21
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.63	5.07	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-13: ATRIUM 10XM Interior Fuel Bundles TLO $MCPR_p$ Limits for TSSS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2 and 7)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	2.57	2.57	2.24	2.02		1.43
	> 60	2.68	2.68	2.26			
TBVOOS	≤ 60	3.41	3.41	2.62	2.04		1.43
	> 60	3.50	3.50	2.79			
MANFRV2*	≤ 60	2.57	2.57	2.24	2.03		1.46
	> 60	2.68	2.68	2.26			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.57	2.57	2.26	2.26	1.76	1.43
	> 60	2.68	2.68	2.26			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	2.76	2.76	2.35	2.17		1.43
	> 60	2.76	2.76	2.35			
TBVOOS	≤ 60	3.56	3.56	2.74	2.18		1.44
	> 60	3.62	3.62	2.88			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	2.76	2.76	2.35	2.26	1.76	1.43
	> 60	2.76	2.76	2.35			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-14: ATRIUM 10XM Peripheral Fuel Bundles TLO $MCPR_P$ Administrative Values for TSSS Insertion Times, EOFPLB to EOCLB (38,023 MWd/MTU CAVEX)

(References 2, 7, and 9)

Nominal FWT							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS/MANFRV1*	≤ 60	7.57	7.57	6.60	5.95		4.21
	> 60	7.89	7.89	6.66			
TBVOOS	≤ 60	10.04	10.04	7.72	6.01		4.21
	> 60	10.31	10.31	8.22			
MANFRV2*	≤ 60	7.57	7.57	6.60	5.98		4.30
	> 60	7.89	7.89	6.66			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	7.57	7.57	6.66	6.66	5.18	4.21
	> 60	7.89	7.89	6.66			
FHOOS							
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**					
		0	**25**	**≤ 38.5**	**> 38.5**	**75**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	8.13	8.13	6.92	6.39		4.21
	> 60	8.13	8.13	6.92			
TBVOOS	≤ 60	10.49	10.49	8.07	6.42		4.24
	> 60	10.66	10.66	8.48			
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	8.13	8.13	6.92	6.66	5.18	4.21
	> 60	8.13	8.13	6.92			

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 4-15: ATRIUM 10XM Interior Fuel Bundles SLO $MCPR_p$ Limits for NSS Insertion Times, All Exposures
(Reference 2)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.59	2.59	2.26	2.13	2.10
TBVOOS	3.43	3.43	2.64	2.13	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.59	2.59	2.26	2.26	2.10
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.78	2.78	2.37	2.13	2.10
TBVOOS	3.58	3.58	2.76	2.13	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.78	2.78	2.37	2.26	2.10

Table 4-16: ATRIUM 10XM Peripheral Fuel Bundles SLO $MCPR_p$ Administrative Values for NSS Insertion Times, All Exposures
(References 2 and 9)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	7.63	7.63	6.66	6.27	6.19
TBVOOS	10.10	10.10	7.78	6.27	6.19
TCV Slow Closure/ PLUOOS/PCOOS	7.63	7.63	6.66	6.66	6.19
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	8.19	8.19	6.98	6.27	6.19
TBVOOS	10.54	10.54	8.13	6.27	6.19
TCV Slow Closure/ PLUOOS/PCOOS	8.19	8.19	6.98	6.66	6.19

Table 4-17: ATRIUM 10XM Interior Fuel Bundles SLO $MCPR_p$ Limits for ISS Insertion Times, All Exposures
(Reference 2)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.59	2.59	2.26	2.13	2.10
TBVOOS	3.43	3.43	2.64	2.13	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.59	2.59	2.27	2.27	2.11
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.78	2.78	2.37	2.13	2.10
TBVOOS	3.58	3.58	2.76	2.13	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.78	2.78	2.37	2.27	2.11

Table 4-18: ATRIUM 10XM Peripheral Fuel Bundles SLO $MCPR_P$ Administrative Values for ISS Insertion Times, All Exposures
(References 2 and 9)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	7.63	7.63	6.66	6.27	6.19
TBVOOS	10.10	10.10	7.78	6.27	6.19
TCV Slow Closure/ PLUOOS/PCOOS	7.63	7.63	6.69	6.69	6.21
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	8.19	8.19	6.98	6.27	6.19
TBVOOS	10.54	10.54	8.13	6.27	6.19
TCV Slow Closure/ PLUOOS/PCOOS	8.19	8.19	6.98	6.69	6.21

Table 4-19: ATRIUM 10XM Interior Fuel Bundles SLO $MCPR_p$ Limits for TSSS Insertion Times, All Exposures
(Reference 2)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.59	2.59	2.26	2.13	2.10
TBVOOS	3.43	3.43	2.64	2.13	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.59	2.59	2.28	2.28	2.13
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	2.78	2.78	2.37	2.19	2.10
TBVOOS	3.58	3.58	2.76	2.20	2.10
TCV Slow Closure/ PLUOOS/PCOOS	2.78	2.78	2.37	2.28	2.13

Table 4-20: ATRIUM 10XM Peripheral Fuel Bundles SLO $MCPR_P$ Administrative Values for TSSS Insertion Times, All Exposures
(References 2 and 9)

Nominal FWT					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	7.63	7.63	6.66	6.27	6.19
TBVOOS	10.10	10.10	7.78	6.27	6.19
TCV Slow Closure/ PLUOOS/PCOOS	7.63	7.63	6.72	6.72	6.27
FHOOS					
EOOS Condition (all include SLO)	**Core Power (% rated)**				
	0	**25**	**≤ 38.5**	**> 38.5**	**50**
Base/TCV Stuck Closed/MSIVOOS	8.19	8.19	6.98	6.45	6.19
TBVOOS	10.54	10.54	8.13	6.48	6.19
TCV Slow Closure/ PLUOOS/PCOOS	8.19	8.19	6.98	6.72	6.27

Table 4-21: ATRIUM 10XM Interior Fuel Bundles $MCPR_f$ Limits
(References 2 and 7)

EOOS Condition*	Core Flow (% rated)	$MCPR_f$ Limit
Base Case / FHOOS / PCOOS / PLUOOS / TCV Slow Closure / PLUOOS and PCOOS in TLO and SLO / MANFRV1 / MANFRV2	0	1.64
	35	1.64
	108	1.18
Any Scenario with One MSIVOOS**	0	1.72
	35	1.72
	108	1.18
Any Scenario with TBVOOS**	0	1.82
	35	1.82
	108	1.35
Any Scenario with 1 Stuck Closed TCV/TSV**	0	1.64
	35	1.64
	108	1.18

* See Section 8 for further operating restrictions.
** "Any Scenario" includes any other combination of allowable EOOS conditions that is not otherwise covered by this table.

Note that the $MCPR_f$ limits for any scenario with 1 stuck closed TCV/TSV are identical to base case $MCPR_f$ limits. This is reflected in the thermal limit sets presented in Table 8-1.

Table 4-22: ATRIUM 10XM Peripheral Fuel Bundles $MCPR_f$ Administrative Values
(References 2, 7, and 9)

EOOS Condition*	Core Flow (% rated)	$MCPR_f$ Limit
Base Case / FHOOS / PCOOS / PLUOOS / TCV Slow Closure / PLUOOS and PCOOS in TLO and SLO / MANFRV1 / MANFRV2	0	4.83
	35	4.83
	108	3.48
Any Scenario with One MSIVOOS**	0	5.07
	35	5.07
	108	3.48
Any Scenario with TBVOOS**	0	5.36
	35	5.36
	108	3.98
Any Scenario with 1 Stuck Closed TCV/TSV**	0	4.83
	35	4.83
	108	3.48

* See Section 8 for further operating restrictions.
** "Any Scenario" includes any other combination of allowable EOOS conditions that is not otherwise covered by this table.

Note that the $MCPR_f$ limits for any scenario with 1 stuck closed TCV/TSV are identical to base case $MCPR_f$ limits. This is reflected in the thermal limit sets presented in Table 8-1.

5. Linear Heat Generation Rate

Technical Specification Sections 3.2.3, 3.4.1, and 3.7.7

The TMOL at rated conditions for the ATRIUM 10XM fuel is established in terms of the maximum LHGR as a function of peak pellet exposure. The LHGR limits for ATRIUM 10XM fuel are presented in Table 5-1.

The power- and flow-dependent LHGR multipliers ($LHGRFAC_p$ and $LHGRFAC_f$) are applied directly to the LHGR limits to protect against fuel melting and overstraining of the cladding during an AOO (Reference 2). In all conditions, the margin to the LHGR limits is determined by applying the lowest multiplier from the applicable $LHGRFAC_p$ and $LHGRFAC_f$ multipliers for the power/flow statepoint of interest to the steady state LHGR limit (Reference 2).

$LHGRFAC_p$ and $LHGRFAC_f$ multipliers were established to support base case and EOOS conditions for all Cycle 27 exposures and scram speeds. The $LHGRFAC_p$ multipliers for ATRIUM 10XM are presented in Table 5-2. The $LHGRFAC_f$ multipliers for ATRIUM 10XM are presented in Table 5-3. The $LHGRFAC_p$ and $LHGRFAC_f$ multipliers are applicable in both TLO and SLO.

The EOOS conditions separated by "/" in these tables represent single EOOS conditions and not any combination of conditions.

Table 5-1: LHGR Limits for ATRIUM 10XM
(References 2 and 7)

Peak Pellet Exposure (MWd/MTU)	LHGR Limit (kW/ft)
0	14.1
18,900	14.1
74,400	7.4

Table 5-2: ATRIUM 10XM LHGRFAC$_p$ Multipliers for All Scram Insertion Times, All Exposures
(References 2 and 7)

Nominal FWT								
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**						
		0	**25**	**≤ 38.5**	**> 38.5**	**50**	**80**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	0.52	0.52	0.58	0.64	0.66	0.88	1.00
	> 60	0.50	0.50	0.58				
TBVOOS	≤ 60	0.38	0.38	0.52	0.64	0.66	0.88	1.00
	> 60	0.36	0.36	0.50				
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	0.52	0.52	0.58	0.64	0.66	0.88	1.00
	> 60	0.50	0.50	0.58				
MANFRV1*	≤ 60	0.52	0.52	0.58	0.62	0.64	0.84	1.00
	> 60	0.50	0.50	0.58				
MANFRV2*	≤ 60	0.52	0.52	0.58	0.60	0.64	0.80	0.96
	> 60	0.50	0.50	0.58				
FHOOS								
EOOS Condition	**Core Flow (% rated)**	**Core Power (% rated)**						
		0	**25**	**≤ 38.5**	**> 38.5**	**50**	**80**	**100**
Base/TCV Stuck Closed/MSIVOOS	≤ 60	0.48	0.48	0.52	0.64	0.66	0.88	1.00
	> 60	0.46	0.46	0.52				
TBVOOS	≤ 60	0.36	0.36	0.49	0.64	0.66	0.88	1.00
	> 60	0.34	0.34	0.46				
TCV Slow Closure/ PLUOOS/PCOOS	≤ 60	0.48	0.48	0.52	0.64	0.66	0.88	1.00
	> 60	0.46	0.46	0.52				

*EOOS conditions MANFRV1 and MANFRV2 are not applicable at power levels below Pbypass (≤ 38.5%).

Table 5-3: ATRIUM 10XM $LHGRFAC_f$ Multipliers for All Cycle 27 Exposures, All EOOS
(References 2 and 7)

Core Flow (% rated)	$LHGRFAC_f$
0.0	0.57
30.0	0.57
80.0	1.00
108.0	1.00

6. Control Rod Block Setpoints

Technical Specification Sections 3.3.2.1 and 3.4.1

The Rod Block Monitor Upscale Instrumentation Setpoints are determined from the relationships shown in Table 6-1.

Table 6-1: Rod Block Monitor Allowable Values
(Reference 3)

ROD BLOCK MONITOR UPSCALE TRIP FUNCTION	ALLOWABLE VALUE
Two Recirculation Loop Operation	0.65 W_d + 56.1%
Single Recirculation Loop Operation	0.65 W_d + 51.4%

W_d – percent of recirculation loop drive flow required to produce a rated core flow of 98.0 Mlb/hr.

The setpoint may be lower/higher and will still comply with the CRWE analysis because CRWE is analyzed unblocked (Reference 2).

7. Stability Protection Setpoints

Technical Specifications Section 3.3.1.3

The OPRM PBDA Trip Settings are provided in Table 7-1.

Table 7-1: OPRM PBDA Trip Settings
(References 2 and 8)

PBDA Trip Amplitude Setpoint (Sp)	Corresponding Maximum Confirmation Count Setpoint (Np)
1.10	13

The PBDA is the only OPRM setting credited in the safety analysis as documented in the licensing basis for the OPRM system (Methodology 2).

The OPRM PBDA trip settings are based, in part, on the cycle specific OLMCPR and the power/flow-dependent MCPR limits. Any change to the OLMCPR values and/or the power/flow-dependent MCPR limits should be evaluated for potential impact on the OPRM PBDA trip settings.

The OPRM PBDA trip settings are applicable when the OPRM system is declared operable, and the associated Technical Specifications are implemented.

8. Modes of Operation

The allowed modes of operation with combinations of equipment out-of-service are as described in Table 8-1. The EOOS conditions separated by "/" in these tables represent single EOOS conditions and not combinations of conditions.

Note that the following EOOS options have operational restrictions: all SLO, all EOOS options with 1 TCV/TSV stuck closed, MSIVOOS, MANFRV1, and MANFRV2. See Table 8-2 for specific restrictions.

Table 8-1: Modes of Operation

(References 2 and 7)

EOOS Option	Thermal Limit Set
Base Case	BASE CASE ➢ TLO or SLO ➢ Nominal FWT or FHOOS
TBVOOS due to Main Generator Load Reject Trip Relays OOS	PLUOOS/TCV SLOW C ➢ TLO for Nominal FWT*
TBVOOS	TBVOOS ➢ TLO or SLO ➢ Nominal FWT or FHOOS
1 TCV/TSV Stuck Closed	BASE CASE ➢ TLO or SLO ➢ Nominal FWT or FHOOS
One MSIVOOS	MSIVOOS ➢ TLO or SLO ➢ Nominal FWT or FHOOS
TCV Slow Closure	PLUOOS/TCV SLOW C ➢ TLO or SLO ➢ Nominal FWT or FHOOS
PLUOOS	PLUOOS/TCV SLOW C ➢ TLO or SLO ➢ Nominal FWT or FHOOS
PCOOS	PLUOOS/TCV SLOW C ➢ TLO or SLO ➢ Nominal FWT or FHOOS
PLUOOS and 1 TCV/TSV Stuck Closed	PLUOOS/TCV SLOW C ➢ TLO for Nominal FWT or FHOOS ➢ SLO for Nominal FWT**
PCOOS and PLUOOS	PLUOOS/TCV SLOW C ➢ TLO for Nominal FWT or FHOOS ➢ SLO for Nominal FWT**
PCOOS and 1 TCV/TSV Stuck Closed	PLUOOS/TCV SLOW C ➢ TLO for Nominal FWT or FHOOS ➢ SLO for Nominal FWT**
MANFRV1	MANFRV1 ➢ TLO for Nominal FWT***
MANFRV2	MANFRV2 ➢ TLO for Nominal FWT***

* SLO and FHOOS cannot be applied for the case of TBVOOS due to main generator load reject trip relays OOS.

** FHOOS cannot be applied to SLO for the cases of PLUOOS and 1 TCV/TSV Stuck Closed, for the case of PCOOS and PLUOOS, or for the case of PCOOS and 1 TCV/TSV Stuck Closed.

*** SLO and FHOOS cannot be applied for the case of MANFRV1 or MANFRV2.

Table 8-2: Core Operational Restrictions for EOOS Conditions
(References 2 and 7)

EOOS Condition	Core Flow (% of Rated)	Core Thermal Power (% of Rated Power)	Rod Line (%)
1 TCV/TSV Stuck Closed PCOOS and 1 TCV/TSV Stuck Closed PLUOOS and 1 TCV/TSV Stuck Closed	N/A	< 75	< 80
One MSIVOOS	N/A	< 75	N/A
SLO	< 51	< 50	N/A
MANFRV1/MANFRV2	N/A	>38.5 (P_{bypass})	N/A

All requirements for all applicable conditions listed in Table 8-2 MUST be met.

Common Notes:

1. All modes are allowed for operation at MELLLA, ICF (up to 108% rated core flow), and coastdown subject to the power restrictions in Table 8-2 (Reference 2). The licensing analysis supports full power operation to EOCLB (38,023 MWd/MTU CAVEX). Note that this value includes coastdown, where full power operation is not expected. Each OOS Option may be combined with each of the following conditions (Reference 2):
    a. Up to 40% of the TIP channels OOS
    b. Up to 50% of the LPRMs OOS
    c. An LPRM calibration frequency of up to 2500 EFPH

2. Nominal FWT results are valid for application within a +10°F/-30ºF temperature band around the nominal FWT curve (Reference 2). For operation outside of nominal FWT, a FWT reduction of up to 120°F is supported for all FHOOS conditions listed in Table 8-1 for cycle operation through EOCLB (Reference 2). At lower power levels, the feedwater temperature reduction is less (Reference 2). Per Reference 6, there is a restriction which requires that for a FWT reduction greater than 100°F, operation needs to be restricted to less than the 100% load line. For a feedwater temperature reduction of between 30ºF and 120°F, the FHOOS limits should be applied.

3. The base case and EOOS limits and multipliers support operation with 8 of the 9 turbine bypass valves operational (i.e., one bypass valve out of service) with the exception of the TBVOOS condition in which all bypass valves are inoperable (Reference 2). Use of the response curve in TRM Appendix H supports operation with any single TBV OOS. TRM Appendix H facilitates analysis with one valve OOS in that the capacity at 0.45 seconds from start of TSV closure is equivalent to the total capacity with eight out of the nine valves in service (Reference 5). The analyses also support Turbine Bypass flow of 29.6% of vessel rated steam flow (Reference 5), equivalent to one TBV OOS (or partially closed TBVs equivalent to one closed TBV), if the assumed opening profile for the remaining TBVs is met. If the opening profile is NOT met, or if the TBV system CANNOT pass an equivalent of 29.6% of vessel rated steam flow, utilize the TBVOOS condition.

4. For the TBVOOS condition, analyses assume zero TBVs trip open and zero TBVs are available for pressure control during the slow portion of the transient analysis (Reference 5). Steam relief capacity is defined in Reference 5.

5. Failure of the main generator load reject trip relays to actuate (e.g., main generator load reject trip relays OOS) will render the turbine bypass valve system inoperable during load reject events (Reference 2). Operation with the main generator load reject trip relays out of service in TLO is supported by the TCV slow closure limits (Reference 2), meaning that, in accordance with Table 8-1, the “PLUOOS/TCV SLOW C” thermal limit set should be applied. This is applicable between 25% and 50% of rated thermal power.

6. Additional operating restrictions apply for both the MANFRV1 and MANFRV2 EOOS options as outlined in Section 1 of Reference 7. These operating restrictions apply when a Feedwater Regulating Valve is placed in manual for conditions as described in the terms and definitions. Only one Feedwater Regulating Valve can be placed in manual. The additional EOOS conditions that are supported with MANFRV1 and MANFRV2 consist of 1 SRVOOS, 40% of TIP channels OOS and 50% of the LPRMs out-of-service. Other conditions associated with base case conditions, such as the feedwater temperature band, the pressure band, single and three-element level control, dome and turbine pressure control, and operation with 1 TBV OOS, are supported as discussed in section 5.1 of Reference 2.

7. The operating administrative values for $MCPR_p$ and $MCPR_f$ are generated to support the recent lost part documented in IR 04410817. If operation will occur using the lost part penalty on limits not listed in the COLR, prior consultation with Nuclear Fuels should occur. Furthermore, this penalty may be removed if all risk of flow blockage from this lost part is removed.

9. Methodology

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in the following documents:

1. GE Topical Report NEDE-24011-P-A, Revision 14, “General Electric Standard Application for Reactor Fuel (GESTAR),” June 2000.

2. GE Topical Report NEDO-32465-A, Revision 0, “Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications,” August 1996.

3. Westinghouse Topical Report CENPD-300-P-A, Revision 0, “Reference Safety Report for Boiling Water Reactor Reload Fuel,” July 1996.

4. Westinghouse Report WCAP-16081-P-A, Revision 0, “10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2,” March 2005.

5. Westinghouse Report WCAP-15682-P-A, Revision 0, “Westinghouse BWR ECCS Evaluation Model: Supplement 2 to Code Description, Qualification and Application,” April 2003.

6. Westinghouse Report WCAP-16078-P-A, Revision 0, “Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel,” November 2004.

7. Westinghouse Topical Report WCAP-15836-P-A, Revision 0, “Fuel Rod Design Methods for Boiling Water Reactors – Supplement 1,” April 2006.

8. Westinghouse Topical Report WCAP-15942-P-A, Revision 0, “Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors Supplement 1 to CENPD-287,” March 2006.

9. Westinghouse Topical Report CENPD-390-P-A, Revision 0, “The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactors,” December 2000.

10. Westinghouse Report WCAP-16865-P-A, Revision 1, "Westinghouse BWR ECCS Evaluation Model Updates: Supplement 4 to Code Description, Qualification and Application," October 2011.

11. Exxon Nuclear Company Report XN-NF-81-58(P)(A), Revision 2 and Supplements 1 and 2, “RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model,” March 1984.

12. Advanced Nuclear Fuels Corporation Report ANF-89-98(P)(A), Revision 1 and Supplement 1, “Generic Mechanical Design Criteria for BWR Fuel Designs,” May 1995.

13. Siemens Power Corporation Report EMF-85-74(P), Revision 0 Supplement 1 (P)(A) and Supplement 2 (P)(A), “RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model,” February 1998.

14. AREVA NP Topical Report BAW-10247PA, Revision 0, “Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors,” February 2008.

15. Exxon Nuclear Company Topical Report XN-NF-80-19(P)(A), Volume 1 Revision 0 and Supplements 1 and 2, “Exxon Nuclear Methodology for Boiling Water Reactors – Neutronic Methods for Design and Analysis,” March 1983.

16. Exxon Nuclear Company Topical Report XN-NF-80-19(P)(A), Volume 4 Revision 1, “Exxon Nuclear Methodology for Boiling Water Reactors: Application of the ENC Methodology for BWR Reloads,” June 1986.

17. Exxon Nuclear Company Topical Report XN-NF-80-19(P)(A), Volume 3 Revision 2, “Exxon Nuclear Methodology for Boiling Water Reactors, THERMEX: Thermal Limits Methodology Summary Description,” January 1987.

18. Siemens Power Corporation Topical Report EMF-2158(P)(A), Revision 0, “Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2,” October 1999.

19. Siemens Power Corporation Report EMF-2245(P)(A), Revision 0, “Application of Siemens Power Corporation’s Critical Power Correlations to Co-Resident Fuel,” August 2000.

20. AREVA NP Report EMF-2209(P)(A), Revision 3, “SPCB Critical Power Correlation,” September 2009.

21. AREVA Topical Report ANP-10298P-A, Revision 1, “ACE/ATRIUM 10XM Critical Power Correlation,” March 2014.

22. AREVA NP Topical Report ANP-10307PA, Revision 0, “AREVA MCPR Safety Limit Methodology for Boiling Water Reactors,” June 2011.

23. Exxon Nuclear Company Report XN-NF-84-105(P)(A), Volume 1 Revision 0 and Volume 1 Supplements 1 and 2, “XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Core Analysis,” February 1987.

24. Advanced Nuclear Fuels Corporation Report ANF-913(P)(A), Volume 1 Revision 1 and Volume 1 Supplements 2, 3, and 4, “COTRANSA2: A Computer Program for Boiling Water Reactor Transient Analyses,” August 1990.

25. Framatome ANP Report EMF-2361(P)(A), Revision 0, “EXEM BWR-2000 ECCS Evaluation Model,” May 2001.

26. Siemens Power Corporation Report EMF-2292 (P)(A), Revision 0, “ATRIUM™-10: Appendix K Spray Heat Transfer Coefficients,” September 2000.

27. Framatome ANP Topical Report ANF-1358(P)(A), Revision 3, “The Loss of Feedwater Heating Transient in Boiling Water Reactors,” September 2005.

28. Siemens Power Corporation Topical Report EMF-CC-074(P)(A), Volume 4 Revision 0, “BWR Stability Analysis: Assessment of STAIF with Input from MICROBURN-B2,” August 2000.

10. References

1. Exelon Generation Company, LLC and MidAmerican Energy Company, Docket No. 50-254, Quad Cities Nuclear Power Station, Unit 1, Renewed Facility Operating License, No. DPR-29.

2. Framatome Report, ANP-3896P, Revision 0, “Quad Cities Unit 1 Cycle 27 Reload Safety Analysis,” January 2021.

3. GE Document, GE DRF C51-00217-01, “Instrument Setpoint Calculation Nuclear Instrumentation, Rod Block Monitor, Commonwealth Edison Company, Quad Cities 1 & 2,” December 14, 1999. (Attachment A to Exelon Design Analysis, QDC-0700-I-1419, Revision 0).

4. Exelon Technical Specifications for Quad Cities 1 and 2, Table 3.1.4-1, “Control Rod Scram Times.”

5. Exelon TODI, NF205719, Revision 0, “Quad Cities Unit 1 Cycle 27 Plant Parameters Document,” July 10, 2020.

6. Exelon Letter, NF-MW:02-0081, “Approval of GE Evaluation of Dresden and Quad Cities Extended Final Feedwater Temperature Reduction,” Carlos de la Hoz to Doug Wise and Alex Misak, August 27, 2002.

7. Framatome Document, FS1-0054583, Revision 1.0, “Supplemental Information for QCI1-27 Reload Safety Analysis Report – Operation with 1 Manual FRV,” February 2, 2021.

8. Exelon TODI, NF210042, Revision 0, “Q1C27 OPRM Setpoint Analysis Request,” January 20, 2021.

9. Exelon Technical Evaluation, EC #633922-000, “Q1R26 Lost Parts Evaluation for IR 04410817,” March 27, 2021.

10. Exelon TODI, NF210212, Revision 0, “Quad Cities Unit 1 Central and Peripheral Orifice Locations,” March 27, 2021.