Core Operating Limits Report

For

Dresden Unit 2 Cycle 29

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Record of Dresden 2 Cycle 29 COLR Revisions

Revision	**Description**
21	Issuance with implementation of TSTF-564 to add $MCPR_{99.9\%}$ and make appropriate language/administrative changes, including those to increase consistency with the Unit 3 COLR
20	Initial issuance for D2C29

1. Terms and Definitions

A10XM	ATRIUM 10XM
Active Control Rods	Total number of control rods minus any inoperable rods
AOO	Anticipated Operational Occurrence
ARO	All Rods Out
ASD	Adjustable Speed Drive
BOC	Beginning of Cycle
Coastdown	Operation beyond end of full power extension techniques, plant power gradually reducing as available core reactivity diminishes
CPR	Critical Power Ratio
CRWE	Control Rod Withdrawal Error
D2C29	Dresden Unit 2 Cycle 29
EFPH	Effective Full Power Hours
EOC	End of Cycle
EOOS	Equipment Out of Service
EOR	End of Rated
FFWTR	Final Feedwater Temperature Reduction
FWHOOS	Feedwater Heater Out of Service
FWRV	Feedwater Regulating Valve
FWT	Feedwater Temperature
GWd/MT	GigaWatt Days per Metric Ton
GWd/ST	GigaWatt Days per Short Ton
ICF	Increased Core Flow
K_p	Off-rated Power Dependent OLMCPR Multiplier
kW/ft	KiloWatts Per Foot
LHGR	Linear Heat Generation Rate
$LHGRFAC_f$	Flow dependent LHGR Multiplier
$LHGRFAC_p$	Power dependent LHGR Multiplier
LOCA	Loss of Coolant Accident
LPRM	Local Power Range Monitor
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
$MCPR_f$	Flow Dependent MCPR
$MCPR_p$	Power Dependent MCPR
$MCPR_{99.9\%}$	Limiting MCPR value such that 99.9 percent of the fuel in the core is expected to avoid boiling transition
MELLLA	Maximum Extended Load Line Limit Analysis
Mlb/hr	Million Pounds per Hour
MOC	Middle of Cycle
MSIVOOS	Main Steam Isolation Valve Out of Service
MWd/MT	MegaWatt Days per Metric Ton

Terms and Definitions (Continued)

MWd/ST	MegaWatt Days per Short Ton
MWth	MegaWatts Thermal
OLMCPR	Operating Limit Minimum Critical Power Ratio
OOS	Out of Service
OPRM	Oscillation Power Range Monitor
PBDA	Period Based Detection Algorithm
P_{bypass}	Reactor power level below which the TSV position and the TCV fast closure scrams are bypassed
PLUOOS	Power Load Unbalance Out of Service
PROOS	Pressure Regulator Out of Service
SLMCPR	Safety Limit Minimum Critical Power Ratio
SLO	Single Loop Operation
SRVOOS	Safety Relief Valve Out of Service
SQR	Station Qualified Reviewer
τ_{ave}	The cycle average scram insertion time for 20% insertion
τ_b	Option B Scram Time Acceptance Criterion
TBSOOS	Turbine Bypass System Out of Service
TBV	Turbine Bypass Valve
TBVOOS	Turbine Bypass Valve Out of Service
TCV	Turbine Control Valve
TCVOOS	Turbine Control Valve Out of Service
TCVSC	TCV Slow Closure
TIP	Traversing Incore Probe
TLO	Two Loop Operation
TMOL	Thermal Mechanical Operating Limit
TRM	Technical Requirements Manual
TSV	Turbine Stop Valve
TSVOOS	Turbine Stop Valve Out of Service

2. General Information

This report is prepared in accordance with Technical Specification 5.6.5 (Reference [4]). The D2C29 reload is licensed by Global Nuclear Fuels. However, some legacy analyses by Framatome are still applicable for A10XM fuel as described in References [2], [9]. The data presented in this report is valid for all the following conditions, from Reference [6]:

- Maximum Extended Load Line Limit down to 95.3% of rated core flow during full power operation (rated core flow is 98 Mlbm/hr).
- Operation up to 108% rated core flow is licensed for this cycle. However, core flow cannot exceed 103.4% rated core flow due to unit specific limitations. For allowed operating regions, see the applicable power/flow map.
- Maximum reduction of 120°F of the feedwater temperature for FWHOOS/FFWTR.
- Coastdown to 40% rated power (Reference [1]) (rated core thermal power is 2957 MWth).
    - Operation at a power level above that which can be achieved with ARO, ICF, FFWTR, and steady-state equilibrium Xenon concentrations is not supported.
- 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.
- For thermal limit monitoring above 108% rated core flow, higher flow values are given in the COLR to be used for linear interpolation. Steady state operation is not allowed in this region. Limits are provided for transient conditions only.
- All thermal limits are analyzed to remain valid with all analyzed scram speeds.
- OLMCPR varies with scram speed as shown in Table 4.1.

See Table 8.2 for EOOS applicable restrictions.

Various EOOS conditions separated by “/” in the COLR represent single EOOS conditions and not any combination of conditions. Refer to the Modes of Operation Section of the COLR for a detailed explanation of allowable EOOS conditions. Combined EOOS conditions are denoted by a “+”.

Table 2.1 defines the three exposure ranges used in the COLR. The term (EOR29 – 2174 MWd/ST) means the projected Cycle 29 EOR exposure minus 2174 MWd/ST of exposure. The value of the EOR29 exposure is based on actual plant operation and is thus determined from cycle projections. The MOC to EOC limits shall be applied prior to the projected EOR29-2174 MWd/ST exposure. For cycle exposure dependent limits at the exact MOC exposure, the more limiting of the BOC to MOC and the MOC to EOC limits should be used. This can be achieved by applying the MOC to EOC limits to the MOC point, as all cycle exposure dependent limits in the MOC to EOC limit sets are the same as, or more limiting than, those in the BOC to MOC limit sets.

Table 2.1: Cycle Exposure Range Definitions
(Reference [6])

Nomenclature	Cycle Exposure Range
BOC to MOC	BOC29 to (EOR29 - 2174 MWd/ST)
MOC to EOC	(EOR29 - 2174 MWd/ST) to EOC29
BOC to EOC	BOC29 to EOC29

3. Average Planar Linear Heat Generation Rate

Technical Specifications Sections 3.2.1 and 3.4.1

Table 3.1 provides the MAPLHGR limit for GNF3. Table 3.2 provides the MAPLHGR limit for A10XM fuel. Limits listed in Tables 3.1 and 3.2 are for TLO. During SLO, the MAPLHGR limits given in Tables 3.1 and 3.2 must be multiplied by a fuel dependent SLO MAPLHGR multiplier provided in Table 3.3.

Table 3.1: MAPLHGR Versus Average Planar Exposure - GNF3
(Reference [6])

Avg. Planar Exposure (GWd/ST)	Avg. Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	0.00	13.45
9.07	10.00	12.91
35.83	39.50	11.32
57.60	63.50	8.00
63.50	70.00	6.00

Table 3.2: MAPLHGR Versus Average Planar Exposure - A10XM
(Reference [2])

Avg. Planar Exposure (GWd/ST)	Avg. Planar Exposure (GWd/MT)	MAPLHGR Limit (kW/ft)
0.00	0.00	12.20
18.14	20.00	12.20
60.78	67.00	7.73

Table 3.3: MAPLHGR SLO Multipliers
(References [2], [6])

Fuel Type	MAPLHGR SLO Multiplier
GNF3	0.78
A10XM	0.80

4. Operating Limit Minimum Critical Power Ratio

<u>Technical Specification Sections 3.1.4, 3.2.2, 3.4.1, and 3.7.7</u>

The OLMCPRs for D2C29 were 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. The cycle-specific SLMCPR, known as $MCPR_{99.9\%}$, can be found in Table 4.7 for dual loop and single loop operating conditions. The values in Table 4.7 were used to calculate the rated and off-rated MCPR limits. The rated OLMCPRs given in Table 4.1 are the maximum values obtained from analysis of the pressurization events, non-pressurization events, and the Option III stability evaluation. MCPR values are determined by the cycle-specific fuel reload analyses in Reference [6].

Tables 4.2-4.5 include MCPR limits and multipliers for various specified EOOS conditions and off rated conditions. 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.

Table 4.1: OLMCPR - GNF3 and A10XM
(Reference [6])

Application Group	TLO/SLO	Exposure Range	Option A		Option B	
			GNF3	A10XM	GNF3	A10XM
Base Case	TLO	BOC-MOC	1.62	1.56	1.50	1.46
		MOC-EOC	1.67	1.59	1.52	1.48
	SLO	BOC-MOC	1.64	1.58	1.52	1.48
		MOC-EOC	1.69	1.61	1.54	1.50
Base Case + TBSOOS	TLO	BOC-MOC	1.65	1.58	1.53	1.51
		MOC-EOC	1.73	1.66	1.58	1.55
	SLO	BOC-MOC	1.67	1.60	1.55	1.53
		MOC-EOC	1.75	1.68	1.60	1.57
Base Case + TCVSC/PLUOOS/PROOS	TLO	BOC-MOC	1.62	1.56	1.50	1.46
		MOC-EOC	1.67	1.59	1.52	1.48
	SLO	BOC-MOC	1.64	1.58	1.52	1.48
		MOC-EOC	1.69	1.61	1.54	1.50
Base Case + 1 FWRV in Manual Mode	TLO	BOC-MOC	1.63	1.57	1.51	1.47
		MOC-EOC	1.69	1.60	1.54	1.49
	SLO	BOC-MOC	1.65	1.59	1.53	1.49
		MOC-EOC	1.71	1.62	1.56	1.51

4.1. Power-Dependent MCPR

For operation less than or equal to 38.5% P_{bypass} core thermal power for all EOOS combinations, the $MCPR_p$ as a function of core thermal power and/or flow is shown in Tables 4.2 and 4.3. For operation greater than 38.5% core thermal power, the MCPR as a function of core thermal power is determined by multiplying the applicable rated condition OLMCPR limit shown in Table 4.1 by the applicable MCPR multiplier K_p found in Table 4.2 and 4.3. K_p is dependent on fuel type, core thermal power, and EOOS condition. $MCPR_p$ values are not provided for power levels below 38.5% for 1 FWRV in Manual Mode because operation in that condition below 38.5% power is not allowed per Reference [6]. K_p values for SLO above 50.0% power and $MCPR_p$ for SLO above 51.0% flow are not provided because operation above 50.0% power or 51.0% flow is not allowed in SLO per Reference [8].

Table 4.2: $MCPR_p$ Limits and Multipliers (K_p) - GNF3
(References [6], [8])

<table>
<tr><th rowspan="3">Application Group</th><th rowspan="3">Core Flow (%)</th><th colspan="11">Core Thermal Power (%)</th></tr>
<tr><th>0.0</th><th>25.0</th><th>≤38.5</th><th>>38.5</th><th>≤50.0</th><th>>50.0</th><th>60.0</th><th>≤75.0</th><th>> 75.0</th><th>85.0</th><th>100.0</th></tr>
<tr><th colspan="3">$MCPR_p$</th><th colspan="8">K_p</th></tr>
<tr><td rowspan="2">Base Case</td><td>≥60.0</td><td>3.30</td><td>3.30</td><td>2.86</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">1.229</td><td rowspan="2">1.164</td><td rowspan="2">1.101</td><td rowspan="2">1.101</td><td rowspan="2">1.099</td><td rowspan="2">1.000</td></tr>
<tr><td><60.0</td><td>2.77</td><td>2.77</td><td>2.68</td></tr>
<tr><td rowspan="2">Base Case + SLO</td><td>>51.0</td><td>--</td><td>--</td><td>--</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td></tr>
<tr><td>≤51.0</td><td>2.79</td><td>2.79</td><td>2.70</td></tr>
<tr><td rowspan="2">Base Case + TBSOOS</td><td>≥60.0</td><td>5.37</td><td>5.37</td><td>3.66</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">1.276</td><td rowspan="2">1.194</td><td rowspan="2">1.113</td><td rowspan="2">1.113</td><td rowspan="2">1.113</td><td rowspan="2">1.000</td></tr>
<tr><td><60.0</td><td>4.02</td><td>4.02</td><td>2.84</td></tr>
<tr><td rowspan="2">Base Case + SLO + TBSOOS</td><td>>51.0</td><td>--</td><td>--</td><td>--</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td></tr>
<tr><td>≤51.0</td><td>4.04</td><td>4.04</td><td>2.86</td></tr>
<tr><td rowspan="2">Base Case + TCVSC/PLUOOS/PROOS</td><td>≥60.0</td><td>3.30</td><td>3.30</td><td>2.86</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">1.517</td><td rowspan="2">1.409</td><td rowspan="2">1.291</td><td rowspan="2">1.101</td><td rowspan="2">1.099</td><td rowspan="2">1.000</td></tr>
<tr><td><60.0</td><td>2.77</td><td>2.77</td><td>2.68</td></tr>
<tr><td rowspan="2">Base Case + SLO + TCVSC/PLUOOS/PROOS</td><td>>51.0</td><td>--</td><td>--</td><td>--</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td></tr>
<tr><td>≤51.0</td><td>2.79</td><td>2.79</td><td>2.70</td></tr>
<tr><td rowspan="2">Base Case + 1 FWRV in Manual Mode</td><td>≥60.0</td><td>--</td><td>--</td><td>--</td><td rowspan="2">1.667</td><td rowspan="2">1.517</td><td rowspan="2">1.229</td><td rowspan="2">1.164</td><td rowspan="2">1.101</td><td rowspan="2">1.101</td><td rowspan="2">1.099</td><td rowspan="2">1.000</td></tr>
<tr><td><60.0</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td rowspan="2">Base Case + SLO + 1 FWRV in Manual Mode</td><td>>51.0</td><td>--</td><td>--</td><td>--</td><td>--</td><td>--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td></tr>
<tr><td>≤51.0</td><td>--</td><td>--</td><td>--</td><td>1.667</td><td>1.517</td></tr>
</table>

Table 4.3: MCPR$_p$ Limits and Multipliers (K$_p$) - A10XM
(References [6], [8])

Application Group	Core Flow (%)	Core Thermal Power (%)										
		0.0	25.0	≤38.5	>38.5	≤50.0	>50.0	60.0	≤75.0	>75.0	85.0	100.0
		MCPR$_p$			K$_p$							
Base Case	≥60.0	3.28	3.28	2.85	1.697	1.537	1.216	1.155	1.094	1.094	1.082	1.000
	<60.0	2.82	2.82	2.73								
Base Case + SLO	>51.0	--	--	--	1.697	1.537	--	--	--	--	--	--
	≤51.0	2.84	2.84	2.75								
Base Case + TBSOOS	≥60.0	5.32	5.32	3.62	1.697	1.537	1.315	1.231	1.102	1.102	1.095	1.000
	<60.0	4.08	4.08	2.82								
Base Case + SLO + TBSOOS	>51.0	--	--	--	1.697	1.537	--	--	--	--	--	--
	≤51.0	4.10	4.10	2.84								
Base Case + TCVSC/PLUOOS/PROOS	≥60.0	3.28	3.28	2.85	1.697	1.537	1.537	1.427	1.310	1.094	1.082	1.000
	<60.0	2.82	2.82	2.73								
Base Case + SLO + TCVSC/PLUOOS/PROOS	>51.0	--	--	--	1.697	1.537	--	--	--	--	--	--
	≤51.0	2.84	2.84	2.75								
Base Case + 1 FWRV in Manual Mode	≥60.0	--	--	--	1.697	1.537	1.216	1.155	1.094	1.094	1.082	1.000
	<60.0	--	--	--								
Base Case + SLO + 1 FWRV in Manual Mode	>51.0	--	--	--	--	--	--	--	--	--	--	--
	≤51.0	--	--	--	1.697	1.537						

4.2. Flow-Dependent MCPR

Tables 4.4 and 4.5 give the OLMCPR limit as a function of the core flow ($MCPR_f$) for GNF3 and A10XM, respectively. These limits are applicable for all analyzed EOOS conditions. $MCPR_f$ values are not provided for SLO above 51.0% rated core flow because operation above 51.0% rated flow is not allowed in SLO per Reference [8].

Table 4.4: $MCPR_f$ Limits - GNF3
(Reference [6])

Core Flow (%)	$MCPR_f$ TLO Limit	$MCPR_f$ SLO Limit
0.00	1.76	1.78
30.0	1.58	1.60
51.0	1.45	1.47
85.2	1.25*	--
112.0	1.25*	--

Table 4.5: $MCPR_f$ Limits - A10XM
(Reference [6])

Core Flow (%)	$MCPR_f$ TLO Limit	$MCPR_f$ SLO Limit
0.0	1.74	1.76
30.0	1.58	1.60
51.0	1.47	1.49
92.2	1.25*	--
112.0	1.25*	--

*This value is lower than the initial MCPR analyzed in the LOCA reports of record. However, because the core monitoring code calculates the off-rated MCPR by taking the maximum of the $MCPR_p$, $MCPR_f$, and OLMCPR, the off-rated MCPR is inherently higher than that analyzed in the LOCA analysis and the LOCA analysis remains applicable at all conditions.

4.3. Scram Time

Option A and Option B refer to use of scram speeds for establishing MCPR operating limits. Option A scram speed time requirements are defined by Technical Specification section 3.1.4. Each operable control rod must demonstrate compliance with these scram times. If not, the rod is declared slow and counts as one of the 12 allowable slow rods per Technical Specification 3.1.4 (Reference [5]).

Option B scram speed time requirements are faster than Option A; therefore, MCPR margin is gained when rods meet the Option B criteria. Option B compliance is determined with a statistical calculation. The cycle average scram insertion time for 20% insertion (τ_{ave}) must be less than or equal to the calculated τ_b in Table 4.6. Two equations are provided for Option B applicability determination in Table 4.6 for convenience of use. The first equation is simpler to apply and is the more conservative of the two equations provided. If Option B requirements are met with the first equation, there is no need to apply the second equation. The second equation can be used if the average scram times do not pass the first equation to meet the Option B requirements using the additional margin the second equation provides.

If the cycle average scram insertion time does not meet the Option B criteria, the appropriate MCPR value may be determined from a linear interpolation between the Option A and B limits as specified by Reference [10].

Table 4.6: Scram Time Option B Applicability Determination
(References [10], [11])

Scram Time Required for Option B Application (secs)
$\tau_{ave} \leq 0.694$ OR $\tau_{ave} \leq 0.694+0.0264 \cdot \sqrt{\frac{N_1}{\sum_{i=1}^{n} N_i}}$

Where N_1 is the number of active control rods measured at BOC, N_i is the number of control rods measured in surveillance test i, and n is the number of surveillances.

4.4. Recirculation Pump ASD Settings

Technical Requirement Manual 2.1.a.1

D2C29 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 [6]); therefore, the recirculation pump ASD must be set to maintain core flow less than 112% (109.76 Mlb/hr) for all runout events.

4.5 Safety Limit MCPR

Technical Specification Section 3.2.2

The cycle-specific SLMCPR, known as $MCPR_{99.9\%}$, can be found in Table 4.7 for dual loop and single loop operating conditions. The values in Table 4.7 were used to calculate the rated and off-rated MCPR limits.

Table 4.7: Cycle Specific SLMCPR ($MCPR_{99.9\%}$) - All Fuel Types
(Reference [6])

Loop Operation	$MCPR_{99.9\%}$ Limit
SLO	1.10
TLO	1.08

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 GNF3 and A10XM fuel is established in terms of the maximum LHGR as a function of peak pellet (rod nodal) exposure. The LHGR limits for GNF3 fuel are presented in Table 5.1. The LHGR limits for A10XM fuel are presented in Table 5.2.

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. 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.

$LHGRFAC_p$ and $LHGRFAC_f$ multipliers were established to support base case and all EOOS conditions for all D2C29 exposures and scram speeds. The $LHGRFAC_p$ multipliers for GNF3 and A10XM are presented in Table 5.3 and Table 5.4, respectively. The $LHGRFAC_p$ multipliers presented in Tables 5.3 and 5.4 are applicable to TLO at all powers and flows listed and SLO at or beneath 51.0% flow and 50.0% power. The $LHGRFAC_f$ multipliers for GNF3 and A10XM are presented in Table 5.5 and Table 5.6, respectively.

$LHGRFAC_f$ values are not provided for SLO above 51.0% rated core flow because operation above 51.0% rated flow is not allowed in SLO per Reference [8]. For GNF3 only, a SLO multiplier is given in Reference [6]; however, it is not used, nor represented, in Table 5.5. This is due to only the limiting multiplier being used and for the case of the SLO applicability flow range, the $LHGRFAC_f$ multipliers are more restrictive than, and thereby bound, the SLO multiplier.

Table 5.1: LHGR Limits - GNF3

(Reference [7], [16])

Peak Pellet Exposure	**UO_2 LHGR Limit**
See Table A-1 of Reference [7]	
Peak Pellet Exposure	**Gadolinia LHGR Limit**
See Table A-2 of Reference [7]	

Table 5.2: LHGR Limits - A10XM

(Reference [9])

Peak Pellet Exposure (GWd/ST)	**Peak Pellet Exposure (GWd/MT)**	**LHGR Limit (kW/ft)**
0.00	0.00	13.40
17.15	18.90	13.40
67.50	74.40	7.10

Table 5.3: $LHGRFAC_p$ Multipliers - GNF3
(Reference [6])

Application Group	Core Flow (%)	Core Thermal Power (%)										
		0.0	25.0	≤38.5	>38.5	≤50.0	>50.0	60.0	≤75.0	>75.0	85.0	100.0
		$LHGRFAC_p$										
Base Case	≥60.0	0.400	0.400	0.440	0.690	0.770	0.870	0.910	0.950	0.950	0.970	1.000
	<60.0	0.440	0.440	0.440								
Base Case + TBSOOS	≥60.0	0.280	0.280	0.360	0.690	0.770	0.830	0.870	0.920	0.920	0.940	1.000
	<60.0	0.370	0.370	0.440								
Base Case + TCVSC/PLUOOS/PROOS	≥60.0	0.400	0.400	0.440	0.690	0.770	0.770	0.820	0.877	0.950	0.970	1.000
	<60.0	0.440	0.440	0.440								
Base Case + 1 FWRV in Manual Mode	≥60.0	--	--	--	0.690	0.770	0.823	0.864	0.895	0.895	0.912	1.000
	<60.0	--	--	--								

Table 5.4: $LHGRFAC_p$ Multipliers - A10XM
(Reference [6])

Application Group	Core Flow (%)	Core Thermal Power (%)										
		0.0	25.0	≤38.5	>38.5	≤50.0	>50.0	60.0	≤75.0	>75.0	85.0	100.0
		$LHGRFAC_p$										
Base Case	≥60.0	0.450	0.450	0.510	0.690	0.770	0.870	0.910	0.950	0.950	0.970	1.000
	<60.0	0.540	0.540	0.550								
Base Case + TBSOOS	≥60.0	0.300	0.300	0.430	0.690	0.770	0.830	0.870	0.920	0.920	0.940	1.000
	<60.0	0.420	0.420	0.550								
Base Case + TCVSC/PLUOOS/PROOS	≥60.0	0.450	0.450	0.510	0.690	0.770	0.770	0.820	0.877	0.950	0.970	1.000
	<60.0	0.540	0.540	0.550								
Base Case + 1 FWRV in Manual Mode	≥60.0	--	--	--	0.690	0.770	0.823	0.864	0.895	0.895	0.912	1.000
	<60.0	--	--	--								

Table 5.5: LHGRFAC$_f$ Multipliers - GNF3
(Reference [6])

Flow (%)	LHGRFAC$_f$ Multiplier TLO	LHGRFAC$_f$ Multiplier SLO
0.00	0.606	0.606
30.0	0.606	0.606
50.0	0.606	0.606
51.0	0.624	0.624
60.0	0.783	--
70.0	0.898	--
80.0	0.966	--
90.0	1.000	--
112.0	1.000	--

Table 5.6: LHGRFAC$_f$ Multipliers - A10XM
(Reference [6])

Flow (%)	LHGRFAC$_f$ Multiplier TLO	LHGRFAC$_f$ Multiplier SLO
0.00	0.429	0.429
30.0	0.535	0.535
50.0	0.606	0.606
51.0	0.624	0.624
60.0	0.783	--
70.0	0.898	--
80.0	0.966	--
90.0	1.000	--
112.0	1.000	--

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 Upscale Instrumentation Setpoints
(Reference [3])

ROD BLOCK MONITOR UPSCALE TRIP FUNCTION	ALLOWABLE VALUE
Two Recirculation Loop Operation	$0.65\ W_d + 55\%$
Single Recirculation Loop Operation	$0.65\ W_d + 51\%$

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 [6]).

7. Stability Protection Setpoints

Technical Specification Section 3.3.1.3

The OPRM PBDA Trip Settings are provided in Table 7.1.

Table 7.1: OPRM PBDA Trip Settings
(Reference [6])

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 (Reference [6]).

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

8.1. Allowable Modes

The allowed modes of operation with equipment OOS and the associated thermal limit sets are as described in Table 8.1. See Table 8.2 for EOOS applicable power and flow restrictions. Common notes are provided in this section to expand on the applicability of the different modes of operation. All thermal limit sets in Table 8.1 have an option for TLO or SLO.

Table 8.1: Modes of Operation
(Reference [6], [8])

EOOS Option *	Thermal Limit Set **
Base Case	BASE
1 TBVOOS (Common Note 3)	BASE
1 SRVOOS (Common Note 8)	BASE
1 MSIVOOS	BASE
1 TCVOOS and/or 1 TSVOOS	BASE
FWHOOS/FFWTR (Common Note 2)	BASE
1 TCVSC	PROOS
PLUOOS	PROOS
PROOS	PROOS
1 FWRV in Manual	MANFRV
TBSOOS (Common Note 4)	TBSOOS

*The Base Case assumptions listed in Common Note 5 apply to all EOOS conditions.

** Full thermal limit set names include designators for scram speed option and number of recirculation loops operating in addition to the EOOS option. The value listed under Thermal Limit Set corresponds to the EOOS option as it appears in the thermal limit set file name. To select the appropriate thermal limit set, the correct scram speed option and number of recirculation loops operating must also be selected.

Table 8.2: Core Thermal Power and Flow Restrictions for EOOS Conditions
(Reference [6], [8]])

EOOS Condition	Core Flow (% of Rated)	Core Thermal Power (% of Rated Power)
1 TCVOOS/TSVOOS*	N/A	< 75
1 MSIVOOS	N/A	≤ 75
SLO	≤ 51	≤ 50
1 FWRV in Manual Mode	N/A	≥ 38.5 (P_{bypass})**

*Operation with 1 TCVOOS and/or 1 TSVOOS is not allowed with TBSOOS.

**Operation with 1 FWRV in manual mode in the fully closed position (e.g., startup and maintenance situations) is exempt from this scenario.

8.2. Common Notes

1. All modes are allowed for operation at MELLLA, ICF, and coastdown subject to the power restrictions in Table 8.2. Coastdown is restricted to 40% rated power. Each OOS Option may be combined with each of the following conditions (Reference [12], [17]):
    a. Up to 50% of the TIP channels OOS
    b. Up to 25% of LPRMs OOS

2. For FWT reduction greater than 100°F, operation is restricted to equal or less than the 100% load line at rated power (Reference [13]). For off-rated conditions, see Table 1b of Reference [13] for FWT reduction.

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 for both fast opening and pressure control opening) except for the TBSOOS condition, in which all bypass valves are inoperable. 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 0.50 seconds from start of TSV closure is equivalent to the total capacity with eight out of the nine valves in service. The analyses also support Turbine Bypass flow of 29.8% of vessel rated steam flow, 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 29.8% of vessel rated steam flow, utilize the TBSOOS condition (Reference [14]).

4. TBSOOS assumes that ALL the TBVs do not trip open on TCV fast closure or TSV closure and that ALL the TBVs are not capable of opening via the pressure control system (Reference [15]). Steam relief capacity is defined in Reference [14].

5. Base Case operation assumes:
    a. 1 MSIVOOS at ≤ 75% rated power (Reference [6])
    b. 1 TCVOOS and/or 1 TSVOOS at <75% rated power (Reference [6])
    c. 1 SRVOOS (Reference [6])
    d. 1 TBVOOS (the fast opening and pressure control opening both OOS) (Reference [6])
    e. FWHOOS/FFWTR (Reference [6])
    f. Operation with a feedwater temperature band of +10°F/-120°F (Reference [6])

6. Between 25% and 50% of rated thermal power, the PROOS thermal limit set ensures that the AOO acceptance criteria are met for a load rejection event if the 86 Device is OOS (Reference [18]). Therefore, use the PROOS thermal limit set between 25% and 50% of rated thermal power if the 86 Device is OOS.

7. Stability BSP regions for Nominal FWT are only applicable from +10°F/-30°F and Stability BSP regions for Reduced FWT are applicable from +10°F/-120°F.

8. 1 SRVOOS is included as an operating flexibility condition in Base Case (Reference [6]), but is not an allowable condition per Reference [19].

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. NEDE-24011-P-A, Revision 31, "General Electric Standard Application for Reactor Fuel," Global Nuclear Fuels, November 2020.
2. NEDO-32465-A, "Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications," GE Nuclear Energy, August 1996.
3. XN-NF-81-58(P)(A), Revision 2 and Supplements 1 and 2, "RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model," Exxon Nuclear Company, March 1984.
4. ANF-89-98(P)(A), Revision 1 and Supplement 1, "Generic Mechanical Design Criteria for BWR Fuel Designs," Advanced Nuclear Fuels Corporation, May 1995.
5. EMF-85-74(P), Revision 0 Supplement 1 (P)(A) and Supplement 2 (P)(A), "RODEX2A (BWR) Fuel Rod Thermal- Mechanical Evaluation Model," Siemens Power Corporation, February 1998.
6. BAW-10247PA, Revision 0, "Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors," AREVA NP, February 2008.
7. XN-NF-80-19(P)(A), Volume 1 and Supplements 1 and 2, "Exxon Nuclear Methodology for Boiling Water Reactors – Neutronic Methods for Design and Analysis," Exxon Nuclear Company, March 1983.
8. XN-NF-80-19(P)(A), Volume 4 Revision 1, "Exxon Nuclear Methodology for Boiling Water Reactors: Application of the ENC Methodology to BWR Reloads," Exxon Nuclear Company, June 1986.
9. XN-NF-80-19(P)(A), Volume 3 Revision 2, "Exxon Nuclear Methodology for Boiling Water Reactors, THERMEX: Thermal Limits Methodology Summary Description," Exxon Nuclear Company, January 1987.
10. EMF-2158(P)(A), Revision 0, "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2," Siemens Power Corporation, October 1999.
11. XN-NF-84-105(P)(A), Volume 1 and Volume 1 Supplements 1 and 2, "XCOBRA-T: A Computer Code for BWR Transient Thermal—Hydraulic Core Analysis," Exxon Nuclear Company, February 1987.
12. EMF-2361(P)(A), Revision 0, "EXEM BWR-2000 ECCS Evaluation Model," Framatome ANP, May 2001.
13. EMF-2292 (P)(A), Revision 0, "ATRIUMTM-10: Appendix K Spray Heat Transfer Coefficients," Siemens Power Corporation, September 2000.
14. NEDC-33930P, Revision 0, "GEXL98 Correlation for ATRIUM 10XM Fuel," Global Nuclear Fuels, February 2021.
15. 006N8642-P, Revision 1, "Justification of PRIME Methodologies for Evaluating TOP and MOP Compliance for non GNF Fuels," Global Nuclear Fuels, January 2022.

10. References

1. Constellation Energy Generation, LLC, Docket No. 50-237, Dresden Nuclear Power Station, Unit 2 Renewed Facility Operating License No. DPR-19.
2. Framatome Document, ANP-3950P, Revision 0, “Dresden Unit 2 Cycle 28 Reload Safety Analysis,” August 2021.
3. GE Document, GE DRF C51-00217-01, “Instrument Setpoint Calculation Nuclear Instrumentation Rod Block Monitor,” December 1999.
4. Constellation Technical Specifications for Dresden 2 and 3, Section 5.6.5, “Core Operating Limits Report (COLR).”
5. Constellation Technical Specifications for Dresden 2 and 3, Section 3.1.4, “Control Rod Scram Times.”
6. GNF Document, 007N0406, Revision 0, “Supplemental Reload Licensing Report for Dresden Unit 2 Reload 28 Cycle 29,” September 2023.
7. GNF Document, NEDC-33879P, Revision 4, “GNF3 Generic Compliance with NEDE-24011-P-A (GESTAR II),” August 2020.
8. GNF Document, 007N2988, Revision 0, “GNF3 Fuel Design Cycle-Independent Analyses for Dresden Nuclear Power Station Units 2 & 3,” August 2023.
9. Framatome Document, FS1-0065975, Revision 1, "ATRIUM 10XM T-M Design Req and Operating Limits for DRE and QCI Transition Cycles, including 4th Cycle Operation," June 2023.
10. GE Document, Supplement to NEDO-24154 Revision 0, "Supplemental Safety Evaluation For The General Electric Topical Report Qualification Of The One-Dimensional Core Transient Model For Boiling Water Reactors NEDO-24154 and NEDE-24154P Volumes I, II and III," January 1981.
11. GNF Letter, DRF A12-00038-3 Volume 4, "Scram Times versus Notch Position," May 1992.
12. GNF Report, 005N6665, Revision 0, "Exelon BWR Fleetwide Technical Evaluation of 50% TIP Strings Out-of-Service on Methods Uncertainties," March 2020.
13. Constellation Letter, NF-MW:02-0081, “Approval of GE Evaluation of Dresden and Quad Cities Extended Final Feedwater Temperature Reduction,” August 2002.
14. Constellation TODI, NF230273, Revision 0, "Dresden Unit 2 Cycle 29 OPL-3," May 2023.
15. Constellation TODI, NF230174, Revision 0, "Dresden Unit 2 Cycle 29 FRED Form," April 2023.
16. GNF Document, 007N0407, Revision 0, “Fuel Bundle Information Report for Dresden Unit 2 Reload 28 Cycle 29,” September 2023.
17. GE Document, NEDC-32694P-A, Revision 0, “Power Distribution Uncertainty for Safety Limit MCPR Evaluations,” August 1999.
18. Constellation TODI, NF205973, Revision 1, “Dresden GNF3 NFI DIR F0900 Cycle-Independent Transient Analyses Input Transmittal to GNF”, October 2022.
19. Constellation Technical Specifications for Dresden 2 and 3, Section 3.4.3, “Safety and Relief Valves”