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DUANE ARNOLD ENERGY CENTER

SAFER/GESTR - LOCA

LOSS-OF-COOLANT ACCIDENT ANALYSIS

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GENERAL ELECTRIC

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DOCUMENT OUTLINE

LIST OF TABLES

List of Figures

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1.0 INTRODUCTION

The purpose of this document is to provide the results of the loss-of-coolant accident (LOCA) analysis for the Duane Arnold Energy Center (DAEC). The analysis was performed using the approved General Electric (GE) SAFER/GESTR-LOCA Application Methodology.

This analysis of postulated plant LOCAs is provided in accordance with NRC requirements and demonstrates conformance with the ECCS acceptance criteria of 10CFR50.46. The objective of the LOCA analysis contained herein is to provide assurance that the most limiting break size, break location, and single failure combination has been considered for the plant. The required documentation for demonstrating that these objectives have been satisfied is given in Reference 1. The documentation contained in this report is intended to satisfy these requirements.

A description of the LOCA models and their application is contained in Reference 2. A value of the peak cladding temperature (PCT) for use in licensing evaluations is determined by adding a term to a PCT value calculated using nominal inputs. The resulting PCT value conforms to all the requirements of 10CFR50.46 and Appendix K.

2.0 DESCRIPTION OF MODEL

The General Electric evaluation model used for the DAEC loss-of-coolant accident (LOCA) analysis consists of four major computer codes (Reference 2). The LAMB and SCAT models are employed for short term system response and hot fuel assembly calculations. The long term level and inventory calculations and final fuel rod heatup calculations are performed by SAFER, with gap conductance supplied by GESTR-LOCA. Figure 1 shows a flow diagram of the usage of these computer codes, indicating the major code functions and the transfer of major data variables.

2.1 LOCA Analysis Computer Codes

2.1.1. LAMB

This code is used to analyze the short-term blowdown phenomena for large postulated pipe breaks (breaks in which nucleate boiling is lost before the water level drops and uncovers the active fuel) in jet pump reactors. The LAMB output (most importantly core flow as a function of time) is input to the SCAT code for calculation of blowdown heat transfer and fuel dryout time.

2.1.2 SCAT

This code completes the transient short-term thermal-hydraulic calculation for large recirculation line breaks in jet pump reactors. A boiling transition correlation is used to predict the time and location of boiling transition during the period that the recirculation pumps are coasting down. When the core inlet flow is low, SCAT uses a dryout correlation to predict the resulting time and location of bundle dryout. The calculated fuel dryout time is input to the long-term thermal-hydraulic transient model, SAFER.

2.1.3 SAFER

This code is used to calculate the long term system response of the reactor for reactor transients over a complete spectrum of hypothetical break sizes and locations. SAFER is compatible with the GESTR-LOCA fuel rod model for gap conductance and fission gas release. SAFER tracks, as a function of time, the core water level, system pressure response, ECCS performance, and other primary thermal-hydraulic phenomena occurring in the reactor. SAFER realistically models all regimes of heat transfer which occur inside the core during the event, and provides the outputs as a function of time for heat transfer coefficients and PCT.

2.1.4 GESTR-LOCA

The GESTR-LOCA code is used to initialize the fuel stored energy and fuel rod fission gas inventory at the onset of a postulated LOCA for input to SAFER. GESTR-LOCA also initializes the transient pellet-cladding gap conductance for input to both SAFER and SCAT.

3.0 ANALYSIS PROCEDURE

3.1 BWR 3/4 Generic Analysis

For the BWR 3/4 product lines, an Appendix K conformance calculation was performed for the limiting break. The limiting break was determined from the nominal break spectrum at that break size and ECCS component failure combination that yielded the highest nominal PCT. The Appendix K calculation was established as the basis for licensing evaluation and determining reactor operating limits.

The PCT calculated as described above maintains margin for licensing evaluations; i.e., the licensing basis PCT is at least the upper 95th percentile PCT. This was verified by separate calculations to determine the upper 95th probability values of PCT at the most limiting conditions determined from the nominal break spectrum calculations. These calculations were performed to qualify the "Appendix K Procedure" as being sufficiently conservative.

*

was found to be the limiting break in the nominal break spectrum for BWR 3/4 product lines. As a result, this case was used to perform the Appendix K calculation. The results of the Appendix K calculation demonstrate that a discharge coefficient of in the Moody Slip Flow Model yields the highest calculated PCT. With an adder to account for model differences from nominal and plant variable uncertainties, the BWR 3/4 Licensing Basis PCT is . The Upper Bound PCT (95% probability PCT) was determined to be , demonstrating that a margin of exists from the licensing basis PCT to the 95% probability PCT.

3.2 DAEC Specific Analysis

The specific analysis performed for DAEC consisted of cases for break sizes ranging from 0.1 ft^2 to the DBA recirculation suction break. These cases were run using analysis assumptions for nominal calculations (Table 1). The case with the highest PCT was determined to be the , which became the nominal case (PCT:NOM).

The ECCS Analysis performed for DAEC utilizing the SAFE/REFLOOD set of methods did not include battery failure. A generic study for BWR/3's and BWR/4's (Reference 3) demonstrated that MAPLHGR limits were not affected by considering battery failure, since the limiting break PCT which is the basis for MAPLHGR did not change.

The limiting case was then run again with specifications for the Appendix K PCT (Specified Models) calculation (Table 2). The trends of the DAEC nominal and Appendix K (specified models) PCT results were compared to assure that the trends match those of the generic BWR 3/4 break spectrum curves (Section 3.1).

*General Electric Company Proprietary Information has been deleted.

An adder is calculated as follows:

$$(\text{ADDER})^2 = [(\text{PCT})_{\text{Appendix K}} - (\text{PCT})_{\text{Nominal}}]^2 + \Sigma\ (\delta\ \text{PCT})^2,$$

Where:

$\text{PCT}_{\text{App. K}}$ = peak cladding temperature from App. K specified models calculation;

$\text{PCT}_{\text{Nominal}}$ = peak cladding temperature from nominal case; and

$\Sigma\ (\delta\ \text{PCT})$ = plant variable uncertainty term.

The licensing peak cladding temperature for DAEC is then obtained from

$$(\text{PCT})_{\text{Licensing}} = (\text{PCT})_{\text{Nominal}} + \text{ADDER}.$$

The results are compared to the generic BWR 3/4 results. These results are presented in Section 5.0.

4.0 INPUT TO ANALYSIS

A list of significant plant input parameters to the LOCA analysis is presented in Table 3. The results of the single-failure evaluation are contained in Table 6.

5.0 RESULTS

5.1 Break Spectrum Calculations

A sufficient number of break sizes and ECCS failure combinations were analyzed using nominal inputs so that the shape of the PCT versus break area curve could be determined. At key points in the break spectrum various ECCS component failures were examined to ensure that the limiting failure had been determined.

Three break sizes were performed with Appendix K input assumptions for the limiting failure determined from the nominal break spectrum analysis. These cases satisfy the Appendix K requirement for using the Moody Slip Flow Model with three discharge coefficients between 0.6 and 1.0.

All SAFER/GESTR-LOCA analyses were performed with a bounding MAPLHGR at the most limiting combination of power and exposure. The most limiting power/ exposure combination was determined by performing generic sensitivity studies for each fuel type along the peak power/exposure envelope used for fuel thermal/mechanical design. For P8x8R fuel a bounding MAPLHGR of 13.0 kw/ft was used in the analysis.

The PCT results for all breaks analyzed are summarized in Table 4. For the nominal break spectrum and the three Appendix K cases the

is the limiting break in nominal break spectrum with a calculated peak cladding temperature of . The corresponding PCT for this break with Appendix K specified models was calculated to be . With the Adder applied to the nominal PCT the Licensing Basis PCT becomes .

The limiting fuel type in terms of calculated PCT for this analysis was found to be

The results for GE8X8EB bound those of the LTA311 because the LTA stored energy will be less than GE8X8EB and the PLHGR is the same.

The DAEC SAFER/GESTR-LOCA analysis incorporates relaxed values for some ECCS performance requirements relative to existing technical specifications.

5.2 Alternate Operating Mode Considerations

ARTS/ELLLA

Flow dependent MAPLHGR factors ($MAPFAC_F$) for 8X8, 8X8R, P8X8R and BP8X8R fuel were derived as part of the analysis documented in Reference 4. As stated in Reference 4, these MAPLHGR factors were derived to assure adherence to the fuel thermal-mechanical design basis, and are not impacted by LOCA considerations because margin to the PCT limit exists. The results of the SAFER/GESTR-LOCA analysis demonstrate that even larger margins to the

PCT limit exist than those used as the basis for deriving the $MAPFAC_F$, and so the $MAPFAC_F$ documented in Reference 4 remain valid.

As discussed in Section 5.1, based on the SAFER/GESTR-LOCA Analysis,

. Therefore, the $MAPFAC_F$ documented in Reference 4 may also be applied to all GE 8X8 fuel designs, including GE8X8EB and LTA311.

Single Loop Operation (SLO)

The analyses documented in References 5 and 6 imposed a 0.87 MAPLHGR multiplier for SLO for 8X8, 8X8R, P8X8R and BP8X8R fuel. A different MAPLHGR multiplier was recommended for LTA311. Based on the results of the SAFER/GESTR-LOCA analysis,

, a MAPLHGR multiplier for SLO of 0.87 may be applied to all GE 8x8 designs, including GE8X8EB and LTA311.

5.3 Technical Specification MAPLHGR Limits

Current GE BWR MAPLHGR limits (as a function of exposure) are based on the most limiting value of either the MAPLHGR determined from ECCS limits (PCT) or the MAPLHGR determined from mechanical design analysis limits.

The MAPLHGR limits currently in the DAEC Technical Specifications and documented in Reference 7 remain valid, since they are less than or equal to the bounding MAPLHGR used in the SAFER/GESTR-LOCA analysis, and are therefore conservative.

MAPLHGR limits as a function of exposure for all fuel types are documented in Appendix A.

6.0 CONCLUSIONS

6.1 Generic Calculation

For the BWR 3/4 class of plants, the generic PCT:APP. K versus break size curve exhibits the same trends as the generic PCT:NOM versus break size curve, and the limiting LOCA determined from PCT:NOM calculations is the same as that determined from PCT:APP. K.

6.2 DAEC Calculation

The SAFER/GESTR-LOCA results presented in Section 5.1 demonstrate the applicability to DAEC of the generic PCT:NOM and PCT:APP.K versus break size curves for the BWR 3/4 class of plants. A sufficient number of plant specific PCT points have been evaluated to verify that the shape of the PCT:NOM curve has the same trend as the generic PCT:NOM versus break size curve. The plant specific licensing basis calculations also match the trend of the generic PCT:APP.K versus break size curve.

DAEC

differs slightly from the generic BWR 3/4 ECCS configuration since it is an LPCI loop selection logic plant as opposed to an LPCI-mod plant. This results in the two remaining LPCI pumps injecting into one recirculation loop for DAEC as opposed to one LPCI pump injecting into each recirculation loop for the generic BWR/4. However, the DAEC ECCS configuration is consistent with the generic BWR/4 configuration in terms of how it will impact the calculated PCT. The ECC systems remaining after the limiting single failure for DAEC are identical to the generic BWR 3/4 and all ECC systems inject into the same region of the vessel. Thus, the limiting case LOCA for both DAEC and the generic BWR 3/4 is the

The generic BWR 3/4 evaluation demonstrates that the difference between the nominal and 95th percentile PCT for this case is , resulting in an upper bound PCT of . This difference is composed of a generic modeling bias of plus a plant variable uncertainty term of . The plant variable uncertainty term reflects the sensitivity of the SAFER calculated PCT to uncertainties in decay heat, PLHGR, break flow, initial stored energy and the minimum temperature for film boiling. Since the DAEC ECCS configuration is consistent with the generic BWR 3/4 configuration, it will show similar sensitivities to each of these parameters. Thus the upper bound PCT for DAEC is about which is well below the Licensing Basis PCT of .

With the explicit verification that the Licensing Basis PCT for DAEC is greater than the 95th percentile PCT, the level of safety and conservatism of this analysis is comparable to that provided by the unquantified conservatism of previous evaluation models. Therefore, the requirements of Appendix K are satisfied.

7.0 REFERENCES

1. Memorandum, R. Wayne Houston (NRC) to Frank Miraglia (NRC), "Safety Evaluation Report on General Electric ECCS Evaluation Methodology", May 29, 1984.

2. (General Electric Company Proprietary Information)

3. Letter, R.E. Engel (GE) to P.S. Check (NRC), "DC Power Source Failure for BWR/3&4", November 1, 1978.

4. "Average Power Range Monitor, Rod Block Monitor and Technical Specification Improvement (ARTS) Program for the Duane Arnold Energy Center", NEDO-30813, February 1985.

5. "Duane Arnold Energy Center, Single Loop Operation", NEDO-24272, July 1980.

6. "Duane Arnold Energy Center Power Uprate", NEDO-30603, July 1984.

7. "Loss-of-Coolant Accident Analysis Report for Duane Arnold Energy Center (Lead Plant)," NEDO-21082-03, June 1984 (as amended).

TABLE 1
ANALYSIS ASSUMPTIONS FOR DAEC NOMINAL CALCULATIONS

1.	Decay Heat	1979 ANS
2.	Transition Boiling Temperature	ILOEJE Correlation
3.	Break Flow	1.25* HEM (Subcooled) 1.0* HEM (Saturated)
4.	Metal-Water Reaction	EPRI Coefficients
5.	Core Power	Rated
6.	PLHGR	
7.	Bypass Leakage Coefficients	Nominal
8.	Initial MCPR	
9.	ECCS Water	88 Btu/lbm (120°F)
10.	ECCS Initialization Signals	Drywell Trip + Injection Valve Open + Delay (See Table 3)
11.	ADS	125 Second Time Delay
12.	Stored Energy	Best Estimate GESTR-LOCA
13.	Fuel Rod Internal Pressure	Best Estimate GESTR-LOCA

TABLE 2

SPECIFICATION FOR DAEC APPENDIX K PCT (SPECIFIED MODELS) CALCULATION

1. 1971 ANS + 20% Decay Heat
2. Moody Slip Flow Model with discharge coefficients of 1.0, 0.8, and 0.6
3. Baker-Just Metal Water Reaction Rate
4. Transition boiling allowed during blowdown only until cladding superheat exceeds 300°F
5. 102% bundle power and 102% core power
6. MCPR Limit which conservatively bounds technical specifications.
7. PLHGR consistent with bounding technical specification MAPLHGR for selected fuel type
8. Worst Single Failure
9. Fuel Exposure which maximizes PCT.

TABLE 3

SIGNIFICANT INPUT PARAMETERS USED IN THE LOCA ANALYSIS

A. Plant Parameters

	Nominal	Appendix K
Core Thermal Power (MW_{th})		
Vessel Steam Output (lbm/hr)		
Corresponding Power (%)		
Vessel Steam Dome Pressure (psia)		
Maximum Recirc Line Break Area (sq. ft)		

B. Fuel Parameters

	P8x8R/BP8x8R	GE8x8EB
PLHGR (kw/ft)-Appendix K		
-Nominal		
MAPLHGR (kw/ft)		
Worst Case Nodal† Exposure for ECCS Evaluation (MWd/MTU)		
Initial MCPR - Appendix K		
- Nominal		
Axial Peaking Factor	1.4	1.4
Number of Fueled Rods per Bundle	62	60/62

C. Emergency Core Cooling System Parameters

LPCI System

Vessel Pressure at Which Flow May Commence (psid)

Minimum Rated Flow at Vessel Pressure (psid)

for two pumps (gpm)
three pumps (gpm)
four pumps (gpm)

†Represents the limiting operating condition resulting in the maximum calculated PCT at anytime in the fuel lifetime.

TABLE 3

SIGNIFICANT INPUT PARAMETERS USED IN THE LOCA ANALYSIS

(Continued)

Initiating Signals and Setpoints
Low-Low-Low Water Level
or
High Drywell Pressure (psig)

Maximum Allowable Time Delay from
Initiating Signal to Pump at Rated Speed (sec)

Injection Valve Fully Open (sec)

Injection Valve Stroke Time (sec)

Maximum Vessel Pressure at Which LPCI
Injection Valve Can Open (psia)

Minimum Break Size for Which Loop Selection
Logic Assumed to Select Unbroken Loop (sq. ft.)

CS System

Vessel Pressure at Which Flow May Commence (psid)

Minimum Rated Flow at Vessel Pressure (psid)
for One System (gpm)

Initiating Signals and Setpoints
Low-Low-Low Water Level
or
High Drywell Pressure (psig)

Minimum Allowed (Runout) Flow (gpm)

Maximum Allowable Delay Time from
Initiating Signal to Pump at Rated Speed (sec)

Injection Valve Fully Open (sec)

Injection Valve Stroke Time (sec)

Maximum Vessel Pressure at Which
LPCS Injection Valve Can Open (psia)

HPCI System

Vessel Pressure at Which Flow May Commence (psia)

Minimum Rated Flow at Vessel Pressure (psia)
(gpm)

TABLE 3

SIGNIFICANT INPUT PARAMETERS USED IN THE LOCA ANALYSIS

(Continued)

Initiating Signals and Setpoints
Low-Low Water Level
or
High Drywell Pressure (psig)

Maximum Allowable Time Delay from
Initiating Signal to Rated Flow
Available and Injection Valve Wide Open (sec)

ADS

Total Number of Valves Installed

Number of Valves Assumed in Analysis

Minimum Flow Capacity of any 3 Valves (lbm/hr)
at Vessel Pressure (psig)

Initiating Signals
Low-Low-Low Water Level

Time Delay After Initiating Signals (sec)

TABLE 4

SUMMARY OF BREAK SPECTRUM RESULTS

- Break Size - Location - Single Failure	PCT (°F)	Peak Local Oxidation %	Core-Wide Metal-Water Reaction %
DBA (App-K-P8x8R Fuel) Recirc Suction Line Break			
DBA (App-K-GE8x8EB Fuel) Recirc Suction Line Break			
DBA (Nominal-P8x8R Fuel) Recirc Suction Line Break			
80% DBA (App-K) Recirc Suction Line Break			
80% DBA (Nominal) Recirc Suction Line Break			
60% DBA (App-K) Recirc Suction Line Break			
60% DBA (Nominal) Recirc Suction Line Break			

TABLE 4

SUMMARY OF BREAK SPECTRUM RESULTS

(Continued)

- Break Size - Location - Single Failure	PCT (°F)	Peak Local Oxidation %	Core-Wide Metal-Water Reaction %
DBA (Nominal) Recirc Suction Line Break			
$1.0ft^2$ (Nominal) Recirc Suction Line Break			
$1.0ft^2$ (Nominal) Recirc Suction Line Break			
$0.5ft^2$ (Nominal) Recirc Suction Line Break			
$0.3ft^2$ (Nominal) Recirc Suction Line Break			
$0.1ft^2$ (Nominal) Recirc Suction Line Break			

TABLE 4

SUMMARY OF BREAK SPECTRUM RESULTS

(Continued)

- Break Size - Location - Single Failure	PCT (°F)	Peak Local Oxidation %	Core-Wide Metal-Water Reaction %
0.21ft² (Nominal) Core Spray Line Break			
1.77ft² (Nominal) Inside Steamline Break			
1.77ft² (Nominal) Outside Steamline Break			
0.51ft² (Nominal) Feedwater Line Break			

NOTES:

TABLE 5

LOCA ANALYSIS FIGURE SUMMARY

Failure	DBA (Nom.)	DBA (App. K)	80% DBA (Nom.)	80% DBA (App. K)	60% DBA (Nom.)	60% DBA (App. K)	DBA (Nom.)	1.0 ft^2 (Nom.)	1.0 ft^2 (Nom.)	0.5 ft^2 (Nom.)	0.3 ft^2 (Nom.)	0.1 ft^2 (Nom.)	Core Spray Line	Steamline (Inside Cont'nmt.)	Steamline (Outside Cont'nmt.)	Feedwater Line
Water Level Inside Shroud	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a	16a	17a
Reactor Vessel Pressure	2b	3b	4b	5b	6b	7b	8b	9b	10a	11b	12b	13b	14b	15b	16b	17b
Peak Cladding Temperature	2c	3c	4c	5c	6c	7c	8c	9c	10c	11c	12c	13c	14c	15c	16c	17c
Heat Transfer Coefficient	2d	3d	4d	5d	6d	7d	8d	9d	10d	11d	12d	13d	14d	15d	16d	17d
Core Average Inlet Flow	2e	3e														
Minimum Critical Power Ratio	2f	3f														
Normalized Power	18															
Peak Cladding Temperature vs. Break Area	19															

TABLE 6

SINGLE-FAILURE EVALUATION

The following table shows the single, active failures considered in the ECCS performance evaluation.

Assumed Failure[1]	Systems Remaining[2]
Battery	ADS, 1 CS, 2 LPCI[3]
LPCI Injection Valve (LPCI IV)	ADS, 2 CS, HPCI
Diesel Generator (D/G)	ADS, 1 CS, HPCI, 2 LPCI
HPCI	ADS, 2 CS, 4 LPCI

(1) Other postulated failures are not specifically considered because they all result in at least as much ECCS capacity as one of the above assumed failures.

(2) Systems remaining, as identified in this table, are applicable to all non-ECCS line breaks. For a LOCA from an ECCS line break, the systems remaining are those listed, less the ECC system in which the break is assumed.

(3) Analyses performed with 1 non-functioning ADS valve in addition to the single failure. See Table 3.

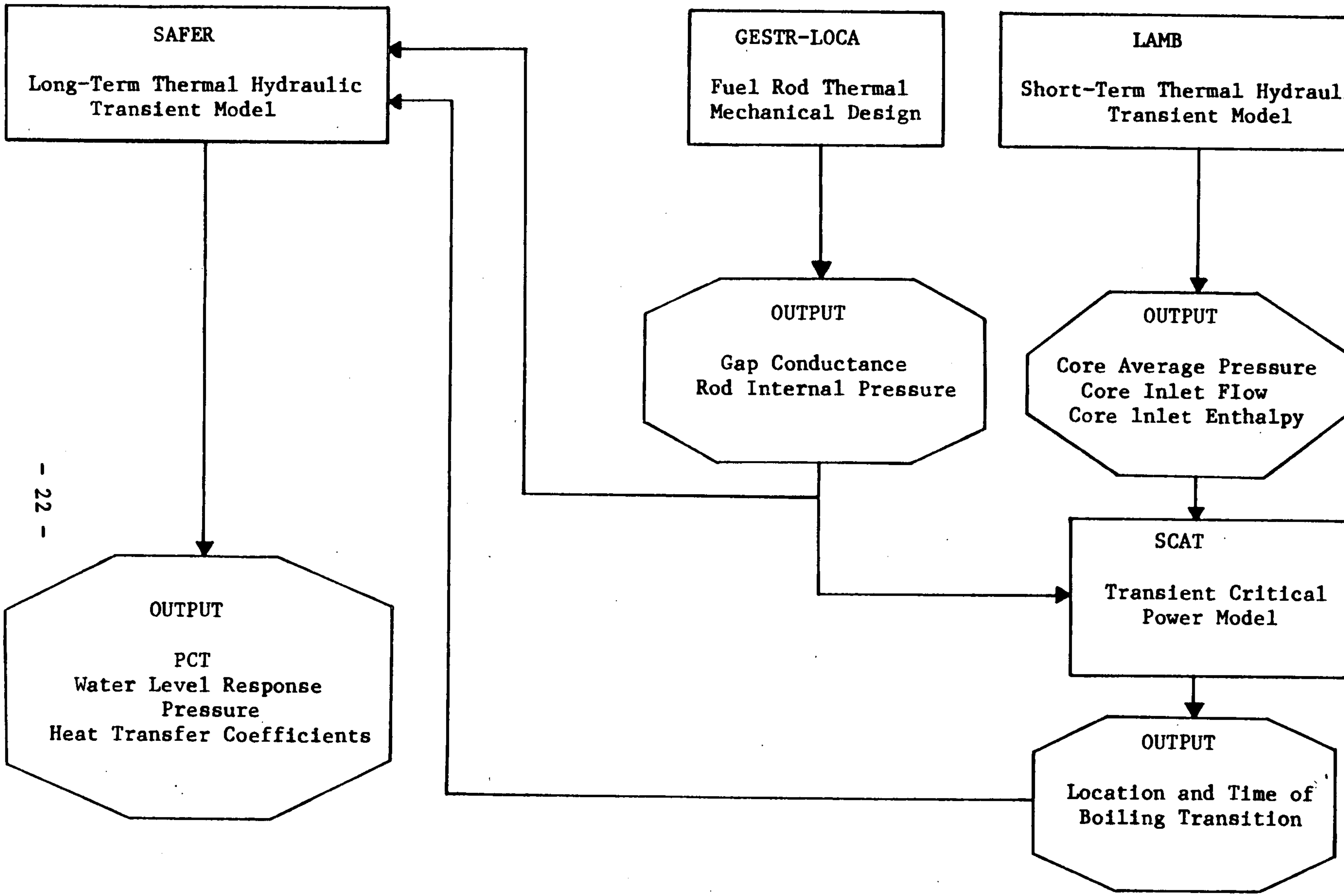

Figure 1. Flow Diagram of Loss-of-Coolant Accident Analysis Using SAFER

FIGURE 2A

(General Electric Company Proprietary Information)

FIGURE 2B

(General Electric Company Proprietary Information)

FIGURE 2C

(General Electric Company Proprietary Information)

FIGURE 2D

(General Electric Company Proprietary Information)

FIGURE 2E

(General Electric Company Proprietary Information)

FIGURE 2F

(General Electric Company Proprietary Information)

FIGURE 3A-1
(General Electric Company Proprietary Information)

FIGURE 3A-2

(General Electric Company Proprietary Information)

FIGURE 3B

(General Electric Company Proprietary Information)

FIGURE 3C-1
(General Electric Company Proprietary Information)

FIGURE 3C-2
(General Electric Company Proprietary Information)

FIGURE 3D-1

(General Electric Company Proprietary Information)

FIGURE 3D-2
(General Electric Company Proprietary Information)

FIGURE 3E
(General Electric Company Proprietary Information)

FIGURE 3F

(General Electric Company Proprietary Information)

FIGURE 4A

(General Electric Company Proprietary Information)

FIGURE 4B

(General Electric Company Proprietary Information)

FIGURE 4C
(General Electric Company Proprietary Information)

FIGURE 4D

(General Electric Company Proprietary Information)

FIGURE 5A

(General Electric Company Proprietary Information)

FIGURE 5B
(General Electric Company Proprietary Information)

FIGURE 5C

(General Electric Company Proprietary Information)

FIGURE 5D

(General Electric Company Proprietary Information)

FIGURE 6A
(General Electric Company Proprietary Information)

FIGURE 6B
(General Electric Company Proprietary Information)

FIGURE 6C

(General Electric Company Proprietary Information)

FIGURE 6D
(General Electric Company Proprietary Information)

FIGURE 7A

(General Electric Company Proprietary Information)

FIGURE 7B

(General Electric Company Proprietary Information)

FIGURE 7C

(General Electric Company Proprietary Information)

FIGURE 7D

(General Electric Company Proprietary Information)

FIGURE 8A

(General Electric Company Proprietary Information)

FIGURE 8B

(General Electric Company Proprietary Information)

FIGURE 8C

(General Electric Company Proprietary Information)

FIGURE 8D

(General Electric Company Proprietary Information)

FIGURE 9A

(General Electric Company Proprietary Information)

FIGURE 9B

(General Electric Company Proprietary Information)

FIGURE 9C

(General Electric Company Proprietary Information)

FIGURE 9D
(General Electric Company Proprietary Information)

FIGURE 10A

(General Electric Company Proprietary Information)

FIGURE 10B

(General Electric Company Proprietary Information)

FIGURE 10C
(General Electric Company Proprietary Information)

FIGURE 10D

(General Electric Company Proprietary Information)

FIGURE 11A

(General Electric Company Proprietary Information)

FIGURE 11B

(General Electric Company Proprietary Information)

FIGURE 11C
(General Electric Company Proprietary Information)

FIGURE 11D

(General Electric Company Proprietary Information)

FIGURE 12A

(General Electric Company Proprietary Information)

FIGURE 12B

(General Electric Company Proprietary Information)

FIGURE 12C

(General Electric Company Proprietary Information)

FIGURE 12D

(General Electric Company Proprietary Information)

FIGURE 13A

(General Electric Company Proprietary Information)

FIGURE 13B

(General Electric Company Proprietary Information)

FIGURE 13C

(General Electric Company Proprietary Information)

FIGURE 13D

(General Electric Company Proprietary Information)

FIGURE 14A

(General Electric Company Proprietary Information)

FIGURE 14B

(General Electric Company Proprietary Information)

FIGURE 14C

(General Electric Company Proprietary Information)

FIGURE 14D

(General Electric Company Proprietary Information)

FIGURE 15A
(General Electric Company Proprietary Information)

FIGURE 15B

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FIGURE 15C

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FIGURE 15D

(General Electric Company Proprietary Information)

FIGURE 16A

(General Electric Company Proprietary Information)

FIGURE 16B

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FIGURE 16C

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FIGURE 16D

(General Electric Company Proprietary Information)

FIGURE 17A

(General Electric Company Proprietary Information)

FIGURE 17B

(General Electric Company Proprietary Information)

FIGURE 17C

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FIGURE 17D
(General Electric Company Proprietary Information)

FIGURE 18
NORMALIZED POWER
DUANE ARNOLD
APPENDIX-K

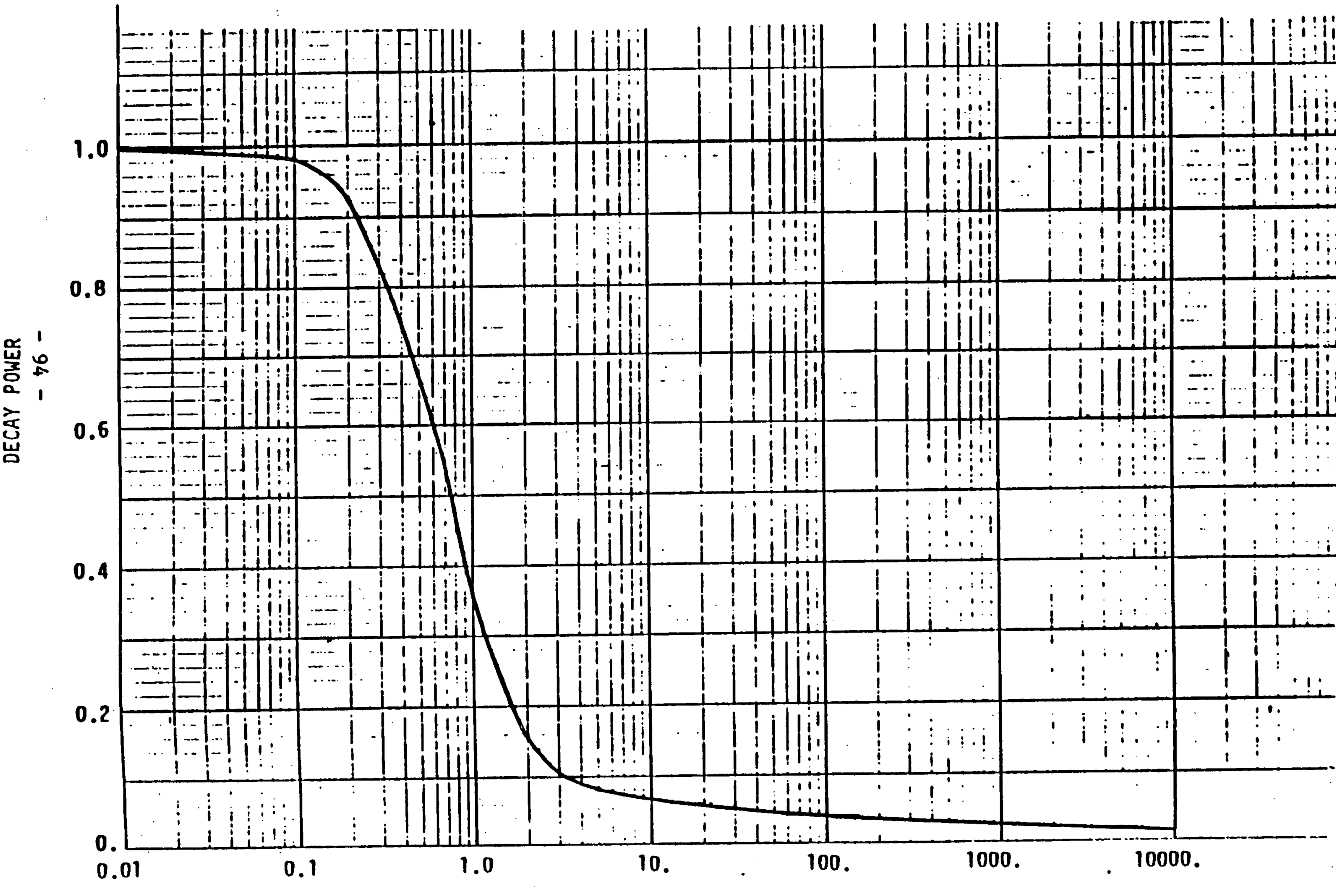

Figure 19 (General Electric Company Proprietary Information)

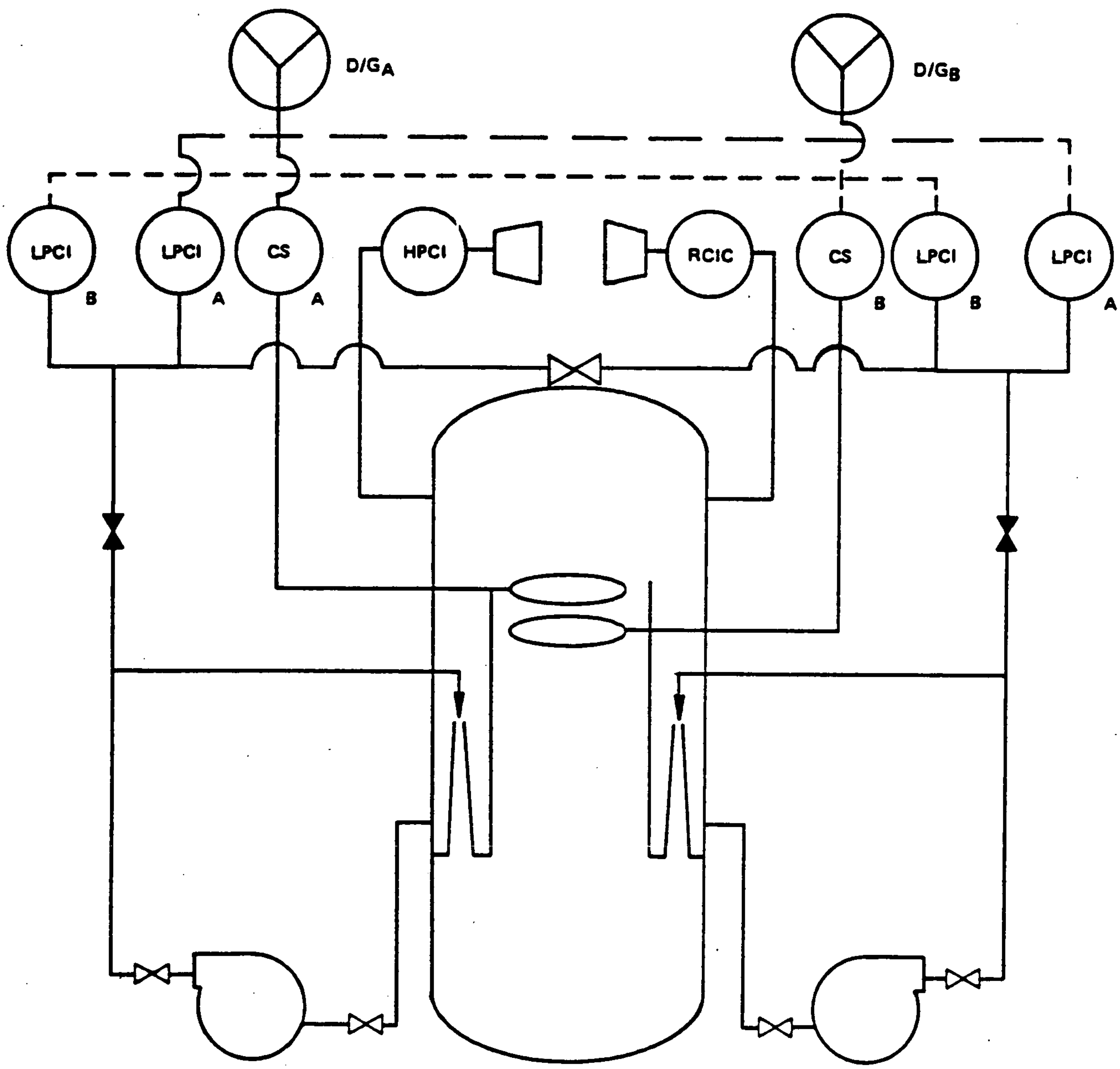

Figure 20 Duane Arnold ECCS Configuration

APPENDIX A: Technical Specification MAPLHGR

1. Bundle Types: P8DRB301L/BP8DRB301L

MAPLHGR LIMITS

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.5
1.0	11.5
5.0	11.9
10.0	12.3
15.0	12.4
20.0	12.2
25.0	11.3
35.0	9.9
45.0	8.7

2. Bundle Types: P8DPB289/BP8DRB289

MAPLHGR Limits

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.2
1.0	11.2
5.0	11.8
10.0	12.0
15.0	12.1
20.0	11.9
25.0	11.4
30.0	10.8
35.0	10.3
40.0	9.6
45.0	8.9

3. Bundle Types: P8DRB284H/BP8DRB284H

MAPLHGR Limits

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.2
1.0	11.2
5.0	11.7
10.0	12.0
15.0	12.0
20.0	11.8
25.0	11.1
30.0	10.4
35.0	9.8
40.0	9.1
45.0	8.5

4. Bundle Types: P8DRB299/BP8DRB299/ELTA

MAPLHGR Limits

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	10.9
1.0	11.0
5.0	11.5
10.0	12.2
15.0	12.3
20.0	12.1
25.0	11.5
30.0	11.0
35.0	10.3
40.0	9.7
45.0	9.0

5. Bundle Type: LTA311

MAPLHGR Limits

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	12.0
1.0	12.1
5.0	12.6
10.0	13.1
15.0	13.5
20.0	13.5
15.0	13.0
30.0	12.2
35.0	11.4
40.0	10.6
50.0	8.9

6. Bundle TYPE: BD299A

MAPLHGR Limits - BD299A/LT1

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.13
2.0	11.36
4.0	11.93
6.0	12.59
8.0	12.93
10.0	13.26
12.5	13.31
15.0	12.76
20.0	12.32
41.9	9.51
50.0	8.00

MAPLHGR Limits - BD299A/LT2

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.65
2.0	11.83
4.0	12.34
6.0	12.87
8.0	13.14
10.0	13.37
12.5	13.33
15.0	13.00
20.0	12.36
42.0	9.59
50.0	8.04

MAPLHGR Limits - BD299A/Nat. U

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.50
2.0	11.28
4.0	11.40
6.0	11.55
8.0	11.66
10.0	11.72
12.5	11.48
15.0	11.16
20.0	10.46
50.0	6.42

7. Bundle Type: BD303A

MAPLHGR Limits - BD303A/LT1

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.53
2.0	11.75
4.0	12.27
6.0	12.69
8.0	12.96
10.0	13.16
12.5	13.22
15.0	12.89
20.0	12.30
41.8	9.65
50.0	8.06

MAPLHGR Limits - BD303A/LT2

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	12.26
2.0	12.43
4.0	12.79
6.0	13.13
8.0	13.29
10.0	13.34
12.5	13.30
15.0	12.97
20.0	12.32
42.1	9.63
50.0	8.11

MAPLHGR Limits - BD303A/LT3

Average Planar Exposure (GWd/St)	MPALHGR (kw/ft)
0.2	12.21
2.0	12.32
4.0	12.61
6.0	12.96
8.0	13.20
10.0	13.28
12.5	13.29
15.0	12.96
20.0	12.31
42.1	9.62
50.0	8.10

MAPLHGR Limits - BD303A/Nat. U

Average Planar Exposure (GWd/St)	MAPLHGR (kw/ft)
0.2	11.50
2.0	11.28
4.0	11.40
6.0	11.55
8.0	11.66
10.0	11.72
12.5	11.48
15.0	11.16
20.0	10.46
50.0	6.42

APPENDIX B: Sensitivity Study Results