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SUBJECT: Provides background info re changes in CPC software constants concerning loss of flow analysis, for review & approval. New analysis of loss of flow event which updates parts of CESSAR FSAR analysis encl.

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July 13, 1987
161-00362-JGH/JRP

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN 50-528 (License NPF-41)
STN 50-529 (License NPF-51)
STN 50-530 (License NPF-65)
CPC Software Revision 3 and Loss of Flow Analysis
File: 87-F-005-419.05; 87-056-026 B, C and D

Dear Sir:

This letter is provided for your review and approval and is intended to provide background information on changes in CPC constants related to Loss of Flow protection which have been determined will prevent reactor trip during a fast bus transfer event at PVNGS. The software changes will be made in accordance with the NRC approved software change procedure (CEN39(A)-P Rev. 03-P-A," CPC Software Protection Algorithm Software Change Procedure", November, 1986). The transient analysis based on the new CPC constants determined that changes to Loss of Flow related COLSS constants are required. The new COLSS constants will be implemented prior to implementation of the revised CPC software.

The attachment provides a new analysis of the Loss of Flow event which updates parts of the CESSAR FSAR analysis. The new analysis assumed a flow coastdown faster than was assumed for the CESSAR FSAR analysis. The revised flow coastdown bounds the coastdowns observed during Unit 1 and Unit 2 startup tests. The overall consequences of the updated Loss of Flow analysis are no less conservative than have been reported previously. The results of the other CESSAR FSAR events were reviewed and the results remain bounding. No Technical Specification changes are necessary as a result of the CPC software change or Loss of Flow analysis.

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In accordance with 10 CFR 170.12(c), the approval fee of $150 has been forwarded to the USNRC License Fee Management Coordinator. If you have any questions regarding these changes, please contact R. A. Bernier of my staff at (602) 371-4295.

Very truly yours,

J. G. Haynes
Vice President
Nuclear Production

JGH/JRP/rw
Attachment

cc: O. M. De Michele
E. E. Van Brunt Jr.
E. A. Licitra (w/a)
R. P. Zimmerman "
G. W. Knighton "
J. B. Martin "
R. M. Diggs (with WFD of $150)

LOSS OF FLOW ANALYSIS FOR REVISED CPC SOFTWARE

The Loss of Coolant Flow (LOF) event is analyzed to determine the minimum initial margin that must be maintained by the Limiting Conditions for Operation (LCO's) such that, in conjunction with the Reactor Protection System (RPS), the DNBR SAFDL (Specified Acceptable Fuel Design Limit) will not be exceeded. This event was reanalyzed due to a change in CPC constants. Protection against Loss of Flow is currently provided by a CPC trip on low DNBR. A projection of decreasing DNBR is performed by the CPC software based on the perceived decreasing flow rate and a conservative derivative of the DNBR with respect to flow. This projection starts from a point which credits the initial margin. The projection is sufficiently conservative such that a rapid trip results for the Loss of Flow event. CPC constants are being modified such that a trip on low Reactor Coolant Pump (RCP) speed becomes the primary trip for the LOF event, replacing the trip on low flow-projected DNBR.

Identification of Causes

A Loss of Coolant Flow may result from a loss of electrical power to one or more of the four reactor coolant pumps. For a Loss of Flow at any power operating condition, a CPC trip will be initiated when the RCP shaft speed drops to 95.0 percent of its nominal speed. Because partial Loss of Flow events are less limiting, only the 4-pump total Loss of Flow event was reanalyzed.

Analysis of Effects and Consequences

The 4-pump Loss of Flow transient is characterized by the flow coastdown curve given in Figure 1. This curve is faster than was assumed for the FSAR analysis. The revised flow coastdown bounds the coastdowns observed during startup testing at PVNGS Units 1 and 2. The 1-D HERMITE space-time code was employed to determine the reactor core response. The core inlet coolant temperature and the system pressure were held constant at their initial values to evaluate the short term DNBR transient as explained in CESSAR Appendix 15A.

The present analysis of the Loss of Flow event considered several cases over the parameter space given in CESSAR Table 15.0-5. The cases chosen for this analysis were determined to be limiting based on previous parametric studies. The single case presented here (Table 1) used the set of initial conditions presented in CESSAR 15.3.1 except the radial peaking factor. The set of initial conditions is one of a very large number of combinations within the parameter space, which would provide the minimum initial margin required by the COLSS power operating limit. The consequences following a total Loss of Flow initiated from any one of these combinations of conditions would be no more adverse than those presented here.

Results

Table 2 presents the sequence of events for the 4-pump Loss of Flow event. This is a representative case with an axial shape index of zero. The CPC low RCP speed trip setpoint is reached at 0.61 seconds. The CEAs start to drop into the core at 1.25 seconds. A minimum CE-1 DNBR above 1.231 is reached at 2.2 seconds. Figures 2 and 3 present the core power and the heat flux as a function of time. The DNBR transient is shown in Figure 4.

Conclusion

The 4-pump Loss of Flow event initiated from the Technical Specification LCO's in conjunction with the CPC trip on low RCP shaft speed does not exceed the DNBR SAFDL. The initial margin required as a result of this analysis is preserved by the DNBR Margin LCO's via an adjustment to COLSS constants. The current Technical Specification DNBR limit used when COLSS is out of service has been shown to be conservative for this analysis.

Table 1

Key Parameters Assumed for the Total Loss of Forced Reactor Coolant Flow Event

Parameter	Units	Reference Analysis Value	Revised Analysis Value
Core Thermal Power	MWt	3876	3876
Initial Core Coolant Inlet Temperature	°F	565	565
Initial Core Flow Rate	10^6 lbm/hr	157.4	157.4
Initial Reactor Coolant System Pressure	psia	2250	2250
Moderator Temperature Coefficient	10^{-4} $\Delta\rho$/°F	0.0	0.0
Radial Power Peaking Factor	--	1.62	1.70
RPS Trip Setpoint	--	Projected DNBR limit	95.0% of nominal shaft speed
Scram Worth at Trip	% $\Delta\rho$	-10.0	-10.0

Table 2

Sequence of Events for Total Loss of Forced Reactor Coolant Flow Event

Time (sec)	Event	Setpoint or Value
0.0	Loss of Power to all Four Reactor Coolant Pumps	---
0.61	Loss Reactor Coolant Pump Shaft Speed Trip Condition	95.0% of nominal shaft speed
0.91	Trip Breakers Open	---
1.25	CEAs Begin to Drop	---
2.20	Minimum CE-1 DNBR	≥ 1.231

EXCESS LOAD TRANSIENT

For the Excess Load Transient, an analysis was performed crediting the low RCP shaft speed CPC trip instead of the flow projected low DNBR CPC trip. The adjusted initial DNBR margin associated with the COLSS constants changes was used. The results of this analysis were found to be bounded by those previously reported in the FSAR.

Steam Line Break (SLB) events with a loss of off-site power are potentially impacted by the proposed software change, as they deal with the loss of flow scenario. The pre-trip consequences, evaluated for the potential to maximize the radiological consequences, were determined to be the same as reported in the FSAR (i.e., no fuel damage). The minimum pre-trip DNBR, as determined for the loss of flow event, remains bounding for the pre-trip SLB with loss of offsite power. The low RCP shaft speed CPC trip time is only 0.01 seconds later than the original trip time (see Table 2A) and the revised COLSS constants provide sufficient initial DNBR margin to mitigate the pre-trip consequences of the event.

For determining the impact of the proposed trip change on the post-trip period during a SLB, the most limiting SLB case analyzed in the FSAR (a full power SLB inside containment with a loss of off-site power) was reanalyzed. The reanalysis credited the low RCP speed trip and more rapid RCP coastdown (to accommodate the effect of electrical braking observed for PVNGS Units 1 and 2). The reanalysis resulted in slightly higher post-trip minimum DNBR than that previously reported in the FSAR (3.92 versus 3.86). In both cases no fuel damage occurs. This increase can be attributed to a slightly lower rate of RCS cooling due to the faster RCP coastdown and a smaller SG inventory available for post-trip RCS cooldown subsequent to a slightly delayed reactor trip. The sequence of events for the revised SLB analysis in comparison with the existing FSAR analysis is shown in Table 1A.

The loss of non-emergency AC power to station auxiliaries (LOAC) events also credits the flow projected low DNBR trip for obtaining acceptable consequences. The discussion on pages 1 and 2 on the impact of the proposed change on the LOF event analysis is directly applicable to the LOAC event since the LOAC is an initiating event for the LOF event.

Table 1A

Sequence of Events for Full Power Large SLB with LOP Event

TIME (SECONDS) FSAR(*)	TIME (SECONDS) REVISED	EVENT DESCRIPTION	SETPOINT OR VALUE FSAR(*)	REVISED
0.0	0.0	Loss of Power to All Four Reactor Coolant Pumps	-	-
0.6	-	Low DNBR Trip Signal Generated, Projected DNBR	1.19	-
		Or SG Delta P Low Flow Trip Signal Generated, percent of initial full power mass flow	70.	-
-	0.61	Low RCP Shaft Speed Trip Condition, percent of initial speed	-	95.0
0.75	0.91	Trip Breakers Open	-	-
1.09(a)	1.25	CEAs Begin to Drop	-	-
7.7	8.2	Voids Begin to Form in RV Closure Head	-	-
9.6	9.4	SG Pressure Reaches MSIS Analysis Setpoint, psia	810.	810.
10.6	10.4	MSIS Generated	-	-
15.2	15.2	AFW Initiated	-	-
15.2	15.5	MSIV Completely Closed	-	-
20.2	21.1	MFIV Completely Closed	-	-
30.0	29.1	Difference Between SGs Pressures Reaches Analysis Setpoint for Lockout of AFW to Ruptured SG, psid	325.	325.
31.0	30.1	Signal to Isolate AFW to Ruptured SG	-	-
46.0	47.0	AFW to Ruptured SG Isolated, AFW Valves to Intact SG Fully Open	-	-

Table 1A
(Continued)

Sequence of Events for Full Power Large SLB with LOP Event

TIME (SECONDS) FSAR(*)	TIME (SECONDS) REVISED	EVENT DESCRIPTION	SETPOINT OR VALUE FSAR(*)	SETPOINT OR VALUE REVISED
86.0	88.5	Pressurizer Empties	-	-
129.0	132.2	Pressurizer Pressure Reaches SIAS Analysis Setpoint, psia	1600.	1600.
130.0	133.2	SIAS Generated	-	-
160.0	163.2	SI Flow Begins	-	-
261.0	266.3	SI Boron Begins to Enter Reactor Core	-	-
315.0	324.3	Affected SG Empties	-	-
325.0	324.3	AFW to Intact SG Terminated, percent of wide range	80.	80.
372.0	382.2	Maximum Post-Trip Reactivity, percent delta rho	+0.05	+0.06
384.0	385.5	Minimum Post-Trip DNBR	3.86	3.92
1800.0	1800.0	Operator Initiates Cooldown	-	-

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note comment

(*) 15.1.5-1, Steam Line Break, (PVNGS FSAR)
(a) 15.3.1-1, Loss of Flow Event (CESSAR FSAR)

Table 2A

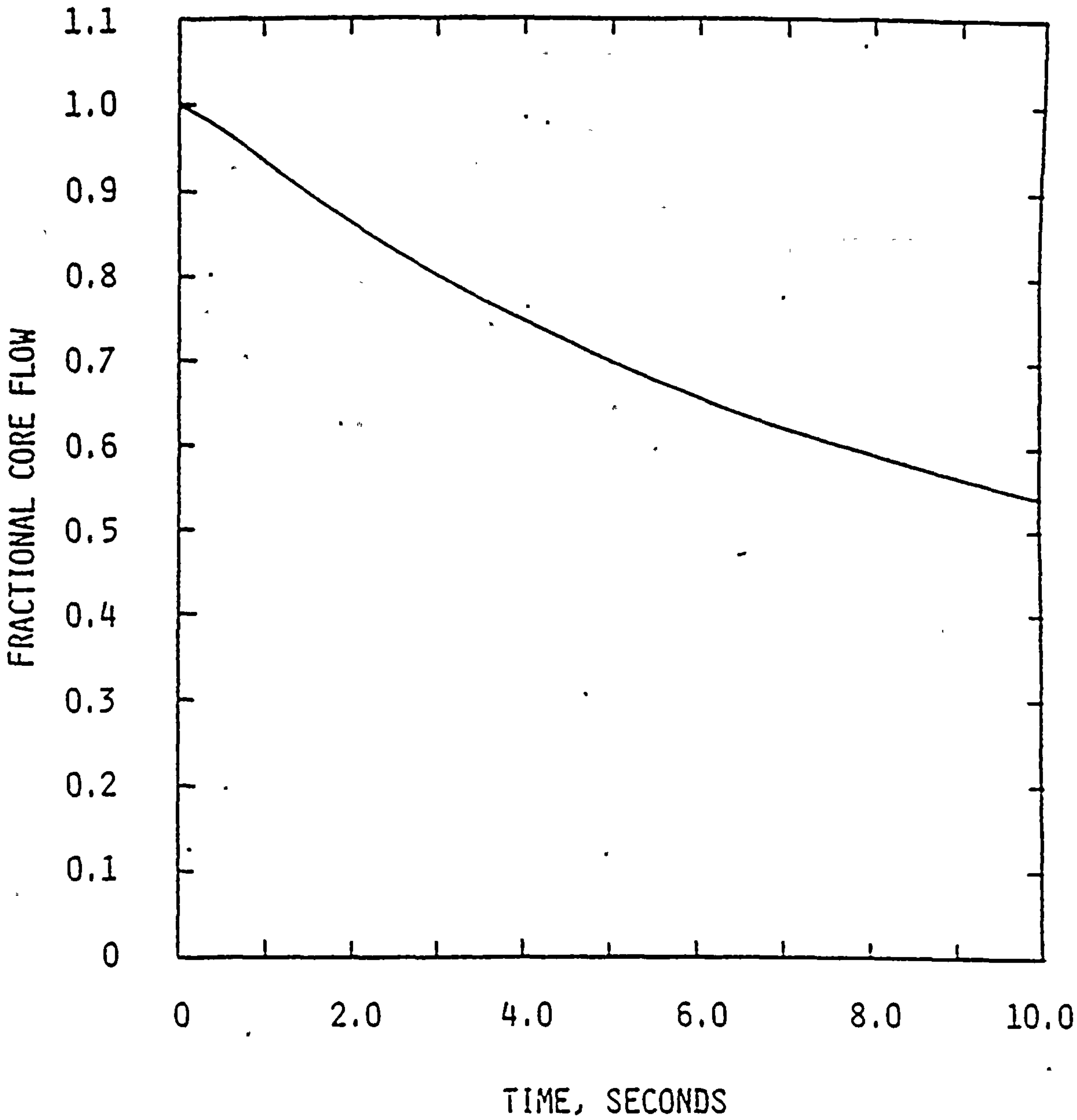
Sequence of Events for Total Loss of Reactor Cooland Flow

TIME (SECONDS) FSAR(*)	TIME (SECONDS) REVISED	EVENT DESCRIPTION	SETPOINT OR VALUE FSAR(*)	REVISED
0.0	0.0	Loss of Power to All Four Reactor Coolant Pumps	-	-
0.6	-	Low DNBR Trip Signal Generated, Projected DNBR	1.19	-
-	0.61	Low RCP Shaft Speed Trip Condition, percent of initial speed	-	95.0
0.75(a)	0.91	Trip Breakers Open	-	-
1.09	1.25	CEAs Begin to Drip	-	-
2.6	2.4	Minimum CE-1 DNBR	1.19	1.231(b)

- -

note comment

(*) 15.3.1-1, Loss of Flow Event, (CESSAR FSAR)
(a) 15.1.5-1, Steam Line Break, (PVNGS FSAR)
(b) minimum DNBR with revised CPS and COLSS constants



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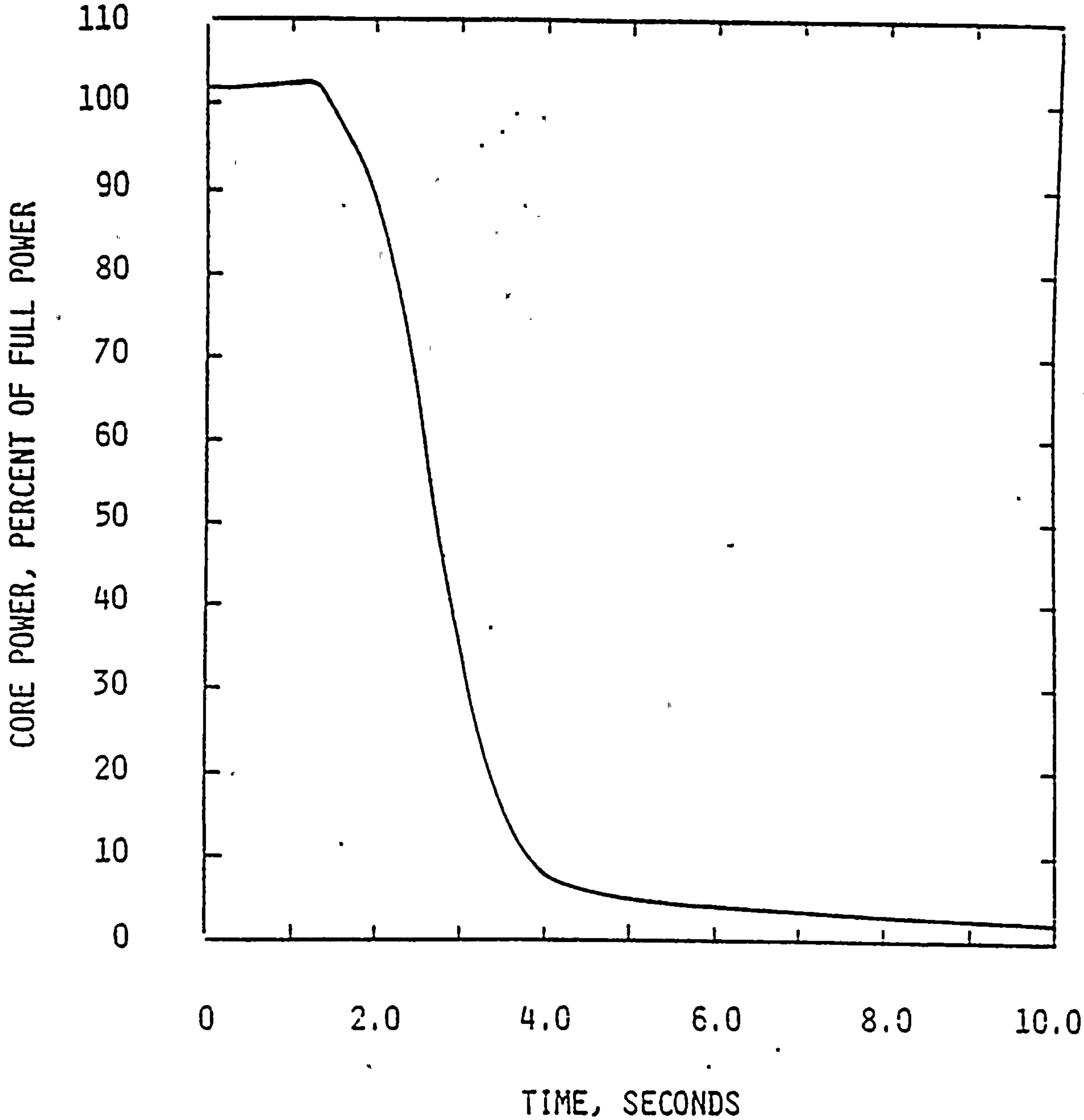
TOTAL LOSS OF REACTOR COOLANT FLOW
CORE FLOW FRACTION VS TIME

Figure 1



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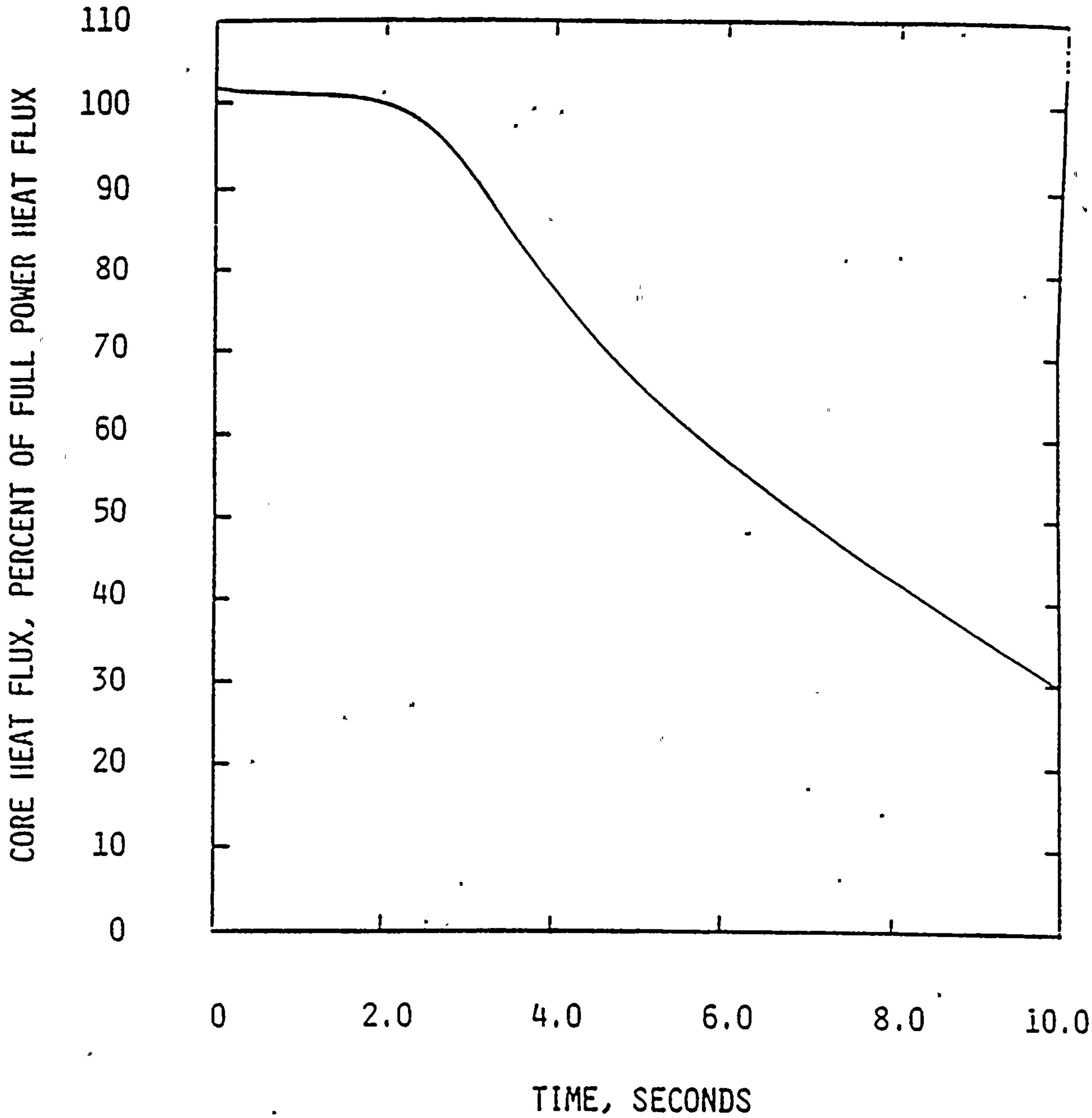
TOTAL LOSS OF REACTOR COOLANT FLOW
CORE POWER VS TIME

Figure 2



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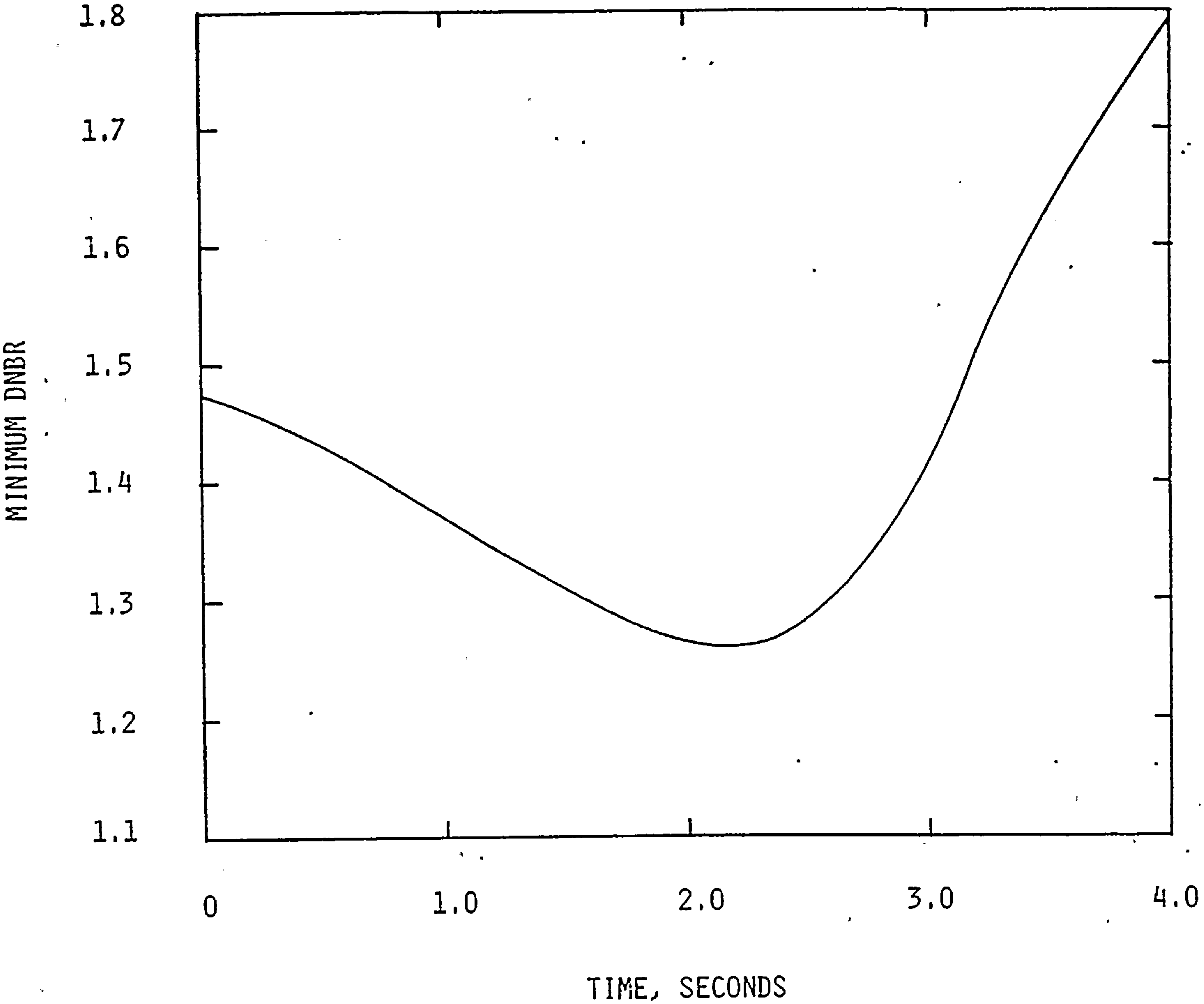
TOTAL LOSS OF REACTOR COOLANT FLOW
CORE HEAT FLUX VS TIME

Figure 3



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TOTAL LOSS OF REACTOR COOLANT FLOW
MINIMUM DNBR VS TIME
Figure 4