Public Service Company of Colorado
16805 Road 19 1/2, Platteville, Colorado 80651

October 12, 1979
Fort St. Vrain
Unit No. 1
P-79235

Mr. George Kuzmycz
U. S. Nuclear Regulatory Commission
Division Project Management
Special Projects
Washington, D. C. 20555

Docket No. 50-267

Subject: Fluctuation Testing
and Revision of RT-500

Reference: 1) P-79211
2) P-78137

Dear Mr. Kuzmycz:

As reported in the Reference 1, Cycle 2 fluctuation testing at about 40% and 50% power levels was performed on August 30, 31 and September 1, 1979. A total of four fluctuation events were recorded on the data systems. Reduction of this data has now been completed and reviewed by both General Atomic Company and Public Service Company of Colorado. Cycle 2 fluctuations have many similar characteristics to those from Cycle 1. However, Cycle 2 fluctuations were generally more core wide with smaller recorded deviations in both linear nuclear channel readings and in module main steam outlet temperatures. The maximum linear nuclear channel deviation from the average was 1.5% (of full power reading) with two events being only 0.5%. Module main steam outlet temperatures were generally in the 20-30°F range with the maximum peak-to-peak value being about 45°F.

Since the above parameters are used during fluctuation testing to determine when a fluctuation has been initiated and when it has stopped after a power reduction, the small value of the deviations made detection difficult with existing instrumentation displays. A total of 14 hours and 45 minutes were spent in a fluctuation operating mode for the four events. This exceeds the predicted estimate in RT-500F, but was unavoidable because of the changed characteristics of Cycle 2 fluctuations.

We have, therefore, revised RT-500 to (1) include a new definition for fluctuations, (2) revise the time to be spent in fluctuations, and (3) provide procedures for a portion of one fluctuation period to be conducted with the steam generator module trim valves in manual

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control. The latter is to determine to what extent trim valve changes which occur during a fluctuation contribute to module main steam temperature deviations. Additionally, modifications in data displays have been implemented to further enhance the ability of the operators and testing personnel to identify a fluctuation with Cycle 2 characteristics:

The revisions outlined above have been incorporated into RT-500, Revision G, a copy of which has been enclosed for your review and information. It should be noted that the definition for fluctuations has been conservatively changed as follows:

> "The plant is defined to be in a fluctuation operating mode when individual nuclear channels exhibit cyclic deviations from the average power equal to or greater than 0.5% peak-to-peak of full power readings not exceeding a 30 minute period."

Table 1 shows a summary of the four Cycle 2 fluctuation events. Note that only the first and marginally the second events constitute a fluctuation by the old definition that the offset be equal to or greater than 1% of the full power reading. The revised definition classifies all four events as fluctuations. Note from Table 1 that the new definition permits detection of a fluctuation event within the first 1/2 hour of the event with improved data displays in the cable room discussed below.

Nuclear Channel deviations of the small magnitude contained in the revised definition are not readily detectable on an absolute scale even when displayed on a narrow range trend recorder. Instrumentation noise and regulating rod movements contribute to identification difficulties. However, the display on a narrow range chart of a nuclear channel minus the average of all six nuclear channels eliminates control rod jogs and permits identification of nuclear channel fluctuation deviations such as those experienced during Cycle 2.

Modifications have been completed which will allow at least three nuclear channels minus the average power to be displayed with a narrow range on the trend recorders in the control room. The fourth trend recorder will be used to display the outlet temperature of Region 20. This region has exhibited the largest temperature swings (up to 62°F peak-to-peak) during Cycle 2 fluctuations.

As previously stated, 14 3/4 hours have been spent in a fluctuation operating mode during testing under RT-500, Revision F, for the four Cycle 2 events. This is in addition to the 65 hours of fluctuations for the 30 events during Cycle 1. The Cycle 2

fluctuation test plan per RT-500 included provisions to do fluctuation testing at about 60 to 70% power levels. The additional testing including a repeat test at each power level would add four fluctuation events. Assuming an additonal 10 hours are spent in a fluctuation mode while the four additional fluctuation tests are conducted, the total time of fluctuations during Cycle 2 prior to installation of region constraint device would be about 25 hours. The total time of fluctuation operation for Cycle 1 plus Cycle 2 is expected to be 90 hours. Both Cycle 1 and Cycle 2 fluctuations exhibit periods of about 10 minutes. Therefore, a maximum of 540 cycles will have occurred prior to installation of the region constraint devices. This is a small fraction of the 10,000 cycles under expected fluctuation load conditions for graphite components within the core which were analyzed for in Reference 2. It is anticipated that the actual time of fluctuation operation for the remaining testing will be less than that assumed.

It is our judgement that the changes to RT-500 contained in Revision G, attached, are largely administrative and do not nulify the prior NRC approval to perform fluctuation testing up to 70% power prior to the installation of the region constraint devices. It is our plan to perform the additional fluctuation tests the week of October 17, 1979.

Very truly yours,

Don W Warembourg

Don W. Warembourg
Manager Nuclear Production

DWW:dkm

Attachment

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Table 1

Fort St. Vrain Cycle 2 Core Temperature Fluctuation Events

Date	Time	% Power Start	Maximum Offset Channel Deviation (Old Definition) %	Maximum Peak-to-Peak Linear Channel Deviation (New)- % First 1/2 Hr.	Maximum Peak-to-Peak Linear Channel Deviation (New) - % Total Event	Maximum Peak-to-Peak Module Main Steam °F
8/30/79	1600-2200	40	1 1/3-1	1.0	1.8	25-35
8/31/79	0318-0830	41	3/4-1	0.7	2.2	35-45
9/01/79	0350-0535	49	1/2	1.1	1.2	30-40
9/01/79	0923-1130	51	1/2	1.0	1.1	20-25

GA RT -500 Revision G
POT REF
REE REF
DATE 10/12/79
ISSUED

REQUEST FOR TEST

REQUESTOR K. Asmussen /W. Simon SYSTEM 12

D PURPOSE/OBJECTIVE - There are two main objectives of this test:

D 1. To determine the fluctuation threshold in terms of core pressure drop
D vs flow (power) for cycle 2 operation.

D 2. To obtain FM data during fluctuations with the revised instrumentation
D systems for comparison with cycle 1 data.

C
C DESCRIPTION OF TEST - With the plant in normal operation, core orifices
D will be adjusted to achieve a specified core pressure drop. Load increases
D in ~3% steps and pulse changes in circulator speed of ~3% will be used as
D trigger mechanisms to induce fluctuations and to determine the fluctuation
D threshold in terms of core pressure drop as a function
D of core flow rate (power level). When a fluctuation occurs, the step
D causing the fluctuation will be repeated to demonstrate repeatability.
D Fluctuations will be initiated first at ~40% power and then at ~10% intervals
D so as to provide a good definition of the stability threshold line. Part 1
D of the test encompases testing at ≤70% power while Part 2 refers to testing
C at >70% power. For at least one fluctuation, FM data will be obtained
D with the reg-rod held in a constant position.
E Revision E incorporates PSC comments on Revision D.
F Revision F incorporates NRC comments on Revision E.
G Revision G incorporates a revised definition of a fluctuation and increases the estimated time spent in a fluctuating mode. These revisions are based on experience gained from RT-500F testing at 40% and 50% power.

ANTICIPATED RESULTS/ACCEPTANCE CRITERIA - The test will provide data to
D aid in predicting conditions for stable operation. Additionally, data
D will be obtained which will aid in understanding the fluctuation phenomenon
D and for comparison with cycle 1 observations. There are no specific anti-
cipated results or acceptance criteria.

REF SOP OR ABNORMAL CONDITIONS - SOP 12-04

SCHEDULE REQUIREMENTS -

SAR & APPROVAL SHEET ATTACHED

WORK ASSIGNED BY R Nirschl 10,12,79 TO PSC Operations /GAC
Name/Date

EVALUATION COMPLETED _____
Name/Date

REVIEWED BY _____
Name/Date

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This SAR is in Support of RT-500 G and is enclosed as Page 2 of 17
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GENERAL ATOMIC COMPANY
FORT ST. VRAIN NUCLEAR GENERATING STATION
SAFETY ANALYSIS REPORT

1. INITIATING DOCUMENT: RT-500 Revision G

		YES	NO
2.	CATEGORY: PLANT CHANGE	[ ]	[X]
	CLASS I	[ ]	[X]
	SAFE SHUTDOWN COOLING	[ ]	[X]
3.	FAILURE MODES AFFECTED	[ ]	[X]
4.	SAFETY RELATED COMPONENT, SYSTEM OR STRUCTURE CHANGE	[ ]	[X]
5.	SAFETY SIGNIFICANT CHANGE	[ ]	[X]
6.	UNREVIEWED SAFETY QUESTION	[ ]	[X]
7.	TECH SPECIFICATION CHANGE	[ ]	[X]
8.	FSAR CHANGE	[ ]	[X]

DOCUMENT CHANGE ONLY [ ]
MAINTENANCE [ ]
TEST [X]

STATE IN ITEM 10 THE BASIS FOR THE BOXES CHECKED

9. APPLICABLE FSAR OR TECH SPEC SECTIONS REVIEWED: T.S. LCO 4.1.4 AND LCO 4.1.7

10. BASIS FOR SAFETY EVALUATION: (Add additional Sheets if Required):
During this test, operation will be within Tech Spec and design limits. The test is performed to investigate the threshold for fluctuations, and although they might be encountered, the time at fluctuation would be minimal. Consequently, any fatigue damage to the core and/or steam generators would be negligible. Main steam temperature fluctuation limits have been set accordingly. In addition, throughout the test, sufficient margin will be maintained between the Tech Spec limit and the region exit temperatures so that even during the most severe fluctuation observed to date the Tech Spec limits will not be violated. (See Figure 1.) Although there will be a period of time that the reg-rod is disabled and not responding to the auto flux (continued on attached sheet)

11. IS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW REQUIRED? YES [ ] NO [X]

12. HAS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW BEEN PERFORMED? YES [ ] NO [ ]

13. Keith Aamussen 10/11/79 — INITIATOR/DATE
A.J. Kennedy 10/11/79 — LICENSING/DATE

14. GAC ENGR. REVIEW/DISPOSITION: I CONCUR WITH THE ABOVE SAFETY ANALYSIS

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ENG'R/DATE Rothrock 10.12.79

This SAR is in Support of RT-500 and is enclosed as Page 2 of 17
of that RT even though the SAR is a separate Uncontrolled Document.

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GENERAL ATOMIC COMPANY
FORT ST. VRAIN NUCLEAR GENERATING STATION
SAFETY ANALYSIS REPORT

1. INITIATING DOCUMENT: RT-500 Revision F

		YES	NO
2.	CATEGORY: PLANT CHANGE		X
	CLASS I		X
	SAFE SHUTDOWN COOLING		X
3.	FAILURE MODES AFFECTED		X
4.	SAFETY RELATED COMPONENT, SYSTEM OR STRUCTURE CHANGE		X
5.	SAFETY SIGNIFICANT CHANGE		X
6.	UNREVIEWED SAFETY QUESTION		X
7.	TECH SPECIFICATION CHANGE		X
8.	FSAR CHANGE		X

DOCUMENT CHANGE ONLY [ ]
MAINTENANCE [ ]
TEST [X]

STATE IN ITEM 10 THE BASIS FOR THE BOXES CHECKED

9. APPLICABLE FSAR OR TECH SPEC SECTIONS REVIEWED: T.S. LOC 4.1.4 AND LCO 4.1.7

10. BASIS FOR SAFETY EVALUATION: (Add additional Sheets if Required):
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11. IS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW REQUIRED? YES [ ] NO [X]

12. HAS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW BEEN PERFORMED? YES [X] NO [ ]

13. Richard Koppenick 8/17/79
INITIATOR/DATE

LICENSING/DATE

14. GAC ENGR. REVIEW/DISPOSITION: I CONCUR WITH THE ABOVE SAFETY ANALYSIS

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ENG'R/DATE L D Scott 8-17-79

FORM: SAR 4/77

10. BASIS FOR SAFETY EVALUATION (continued)

control system, test procedures will assure any required rod runbacks will take place and will produce the subsequent desired reactor power control. Therefore, this test will not adversely affect the integrity of the core or steam generator and will not affect public safety.

Since first being encountered on October 31, 1977, fluctuations have been initiated several times in a continuing effort to understand their cause. The power levels at which fluctuations were initiated have ranged
D from 30% to 68%. A total of about 65 hours has been spent in a fluctuating
D mode, which is equivalent to 390 cycles with a period of ten minutes.

Although the cause of the fluctuations is not known, there are several reasons for concluding that continued testing is safe. The total core
C power, flow, and average temperatures are relatively stable. An inspection of the top plenum in December 1977 after fluctuation testing at power levels between 53% and 68% showed it was in good condition. An inspection at that time of the control rods in region 34 (which were inserted throughout the entire period of fluctuation testing) also showed no signs of excessive
D temperature or impact. During the first refueling outage, eleven blocks
D from region 35 were carefully inspected in the PSC hot service facility
D and there was no evidence of damage. An in-core inspection of region 35
D and its surroundings with the fuel handling machine T.V. camera revealed
D no damage or excessive wear to any component. The upper plenum area
D looked fine; the gaps in the regions and side reflector surrounding the
D cavity left when region 35 was unloaded were very regular with no evidence
D of wear or damage. An inspection of the core support blocks in regions 13 &
D 35 havelikewise revealed no damage.

D Every element removed from the core during the refueling of six
D regions has been photographed as has each block in five additional regions
D which were unloaded to permit installation of test assemblies. Examinations
D of these photographs have revealed no damage.

D Testing Above 70% Power (Part 2)

D Since fluctuations were first encountered, tests have been con-
D ducted under various core conditions. In large part, these tests were
D designed to gather specific information on what key parameter or combina-
D tion of parameters leads to the fluctuations, since this knowledge could
D be instrumental in understanding their cause. These tests have shown
D fairly conclusively that power level is not by itself a parameter of primary
D importance to the fluctuation threshold, and they have established core
D pressure drop as a key parameter, probably closely related to the cause of
D the fluctuations. Another result from these tests is that it appears that
D the core pressure drop at which fluctuations are produced is higher at
D higher core power levels.

D Differences in fluctuation magnitudes and character have been observed
D in the '65 fluctuations that were initiated during cycle 1 operation.
D These differences have been carefully studied and reported extensively.
D No apparent correlation with power level has been noted, nor has a change

D been observed with time that would indicate increasing fluctuation magni-
D tudes or significant differences in character. All of the fluctuation
D testing limits and operating considerations as well as normal plant tech-
D nical specification limits and SOPs are in effect both below 70% power
D and above 70% power. One exception is the limit on nuclear detector
D fluctuations. This limit is increased from 10% at <70% power to 20% for
D >70% power. This increase is justified because nuclear channel fluctua-
D tions are believed to be due primarily to a streaming effect and are thus
D expected to be nearly proportional to the power (neutron flux) level.
D In this test, fluctuations will be initiated at successively higher power
D levels. The magnitude and character of the fluctuations at each power
D level will be carefully observed for differences in addition to monitoring
D the Technical Specification and fluctuation testing limits. Consequently,
D testing above 70% power will not affect public safety.

D Time Spent Fluctuating

D It is anticipated that a total of about 16 fluctuations will be
D initiated during Part 1 of this test (testing ≤70% power). Total time
D in the fluctuating mode during Part 1 is expected to be no more than
G 25 hours. For each of the four power levels at which the fluctuation
F threshold limit will be defined, a first fluctuation will be initiated and
F sustained for a 1-hour period (Step 4B of the Procedure). To verify repeat-
F ability, three additional fluctuations will then be initiated and immediately
F halted at each of these power levels (Steps 5, 6 and 7 of the Procedure).
F One-half (1/2) hour in the fluctuating mode has been allotted for each of the
F latter three fluctuations. In addition, for one fluctuation during the
F conduct of this RT, the fluctuation will be sustained for one-half (1/2) hour
G with the reg-rod disabled and all rods held in a constant position and for (1/2)
G hour with the trim valves in manual (Part 1, Step 4C of the Procedure).

G The additional time spent in the fluctuating mode has been increased due to
G experience obtained from testing with RT-500F at 40 and 50% power. Cycle 2
G fluctuations obtained at those powers exhibited similar characteristics to
G Cycle 1 except that the linear nuclear channel deviation from the average was
G smaller. For two of the fluctuation events, they were as small as 0.5%. Since
G these parameters are used to determine when a fluctuation has been initiated and
G when it has terminated, the small value of the deviation made detection difficult.
G To date, a total of 14 hours and 45 minutes have been spent in the fluctuation
G mode and tests still remain to be done between 60 and 70% reactor power.

D During Part 2 of this test (testing at > 70% power), fluctuations may be
D initiated about 8 times, with a total time in the fluctuation mode of ∿ 4 hours.

PREFACE

Revision A accomplished the following changes: (1) The Operating Limits Section was redefined to incorporate limits required by the NRC. (2) The remainder of the previous limits were redesignated as Operating Considerations. (3) The equation for core resistance was redefined to better fit observed operating data. (4) Addendum I was added to determine the fluctuation threshold at 28% power.

Revision B accomplished the following changes: (1) The 10% limit on a nuclear channel fluctuation was extended to cover all six channels. (2) The required instrumentation was increased to have brush recorders for all twelve steam generator module outlet temperatures and all six nuclear channels; the steam generator temperatures will be monitored both by wide range brush recorders (700°F - 1100°F) and by either narrow range brush recorders (100°F range, zero suppressed) or digital display of fluctuation magnitudes from the steam generator data acquisition system. (3) The limit on module main steam temperature at which testing is suspended until authorized by PSC management is increased from ±30°F to 150°F. (4) In Figure 1, the region temperature mismatch margin for region 12 is increased to 100°F. (5) The instruments to be monitored by the trend recorders are not specified: any four thought to be of most use may be trended. (6) A two hour waiting period between fluctuation tests is specified.

Revision C accomplished the following changes: (1) Corrective action is to be taken to stop the fluctuation if a module main steam temperature reaches 1025°F. (2) Editorial changes were made to the other limits on module main steam temperature. (3) The test team members responsible for conducting the test are specified. (4) The physical location of the data systems to be monitored are specified, as are the respective team members responsible for monitoring them. (5) Figure 2 of Addendum I has been "cleaned up" and updated to reflect the current actual locations for thermocouples 3, 4, 5, 7, 19, 23, and 25. (6) In Figure 1, the region temperature mismatch margin on regions 17, 18, 26, and 27 have been increased.

Revision D accomplished the following changes: (1) The detailed test procedure has been rewritten. The number of anticipated fluctuations and the total time spent in the fluctuation mode has been reduced. However, the basic test philosophy and the limits during fluctuations remain unchanged. (2) RT-502 (Threshold Testing >70% Power) has been incorporated as Part 2 of this RT. (3) The objectives of the test have been modified to reflect testing during cycle 2 (for comparison with cycle 1) with the emphasis on gathering data to aid in predicting conditions for stable operation. (4) Addendum I of RT-500 Revision C has not been repeated here because it was successfully completed during cycle 1 testing. (5) A definition of a fluctuation has been included. (6) There have been numerous editorial changes (changes are denoted by a D in the margin).

Revision E incorporates comments from PSC to delete the detailed orifice adjustment procedure, update Data Sheet 1 to include all limits and other minor comments as noted in the left margin.

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Revision F incorporates comments from NRC as noted.

Revision G incorporates a revised definition of a fluctuation and increases the estimated time spent in a fluctuating mode. These revisions are based on experience gained from RT-500F testing at 50% and 60% power. The increased time is the result of approximately 15 hours spent in a fluctuation mode during completion of the first half of RT-500F.

INTRODUCTION

D The collection of data from all cycle 1 core fluctuations indicates a distinct influence of core ΔP on the threshold for fluctuations. However, D the cycle 1 data shows a lot of scatter and fresh fuel has been loaded D into six regions of the core; therefore, fluctuation threshold testing at D the beginning of cycle 2 is necessary.

D This RT will determine the fluctuation threshold as a function of D core pressure drop for cycle 2 (with a procedure aimed at minimizing D the amount of scatter in the data). The FM Data System now includes D 24 traversable thermocouples, PCRV displacement probes and magnetometers D for attempting to monitor core barrel motion, and two instrumented control D and orificing assemblies having in-core instrument packages. These data D will be collected during fluctuations to aid in predicting conditions for D stable operation and in understanding the fluctuation phenomenon.

D The expected methods for triggering a fluctuation will be a 3% load D increase at 3% per minute and a pulse change in circulator speed sufficient D to produce ~3% increase in flow. When a fluctuation develops, the steps D preceding and resulting in the fluctuation will be repeated to demonstrate D repeatability and to provide a reasonably accurate determination of the D threshold power.

The test scope includes the determination of the fluctuation D threshold for at least three values of core flow resistance.

Testing will be conducted by the coordinated efforts of a test team consisting of, but not limited to, the following members:

1. PSC Shift Supervisor
2. PSC Reactor Operator(s)
D 3. Test Coordinator
D 4. Core Performance Engineer
D 5. Data Systems Engineer

F The NRC will be provided, within one week, with a summary of test results for F each power level. Included with these results will be notification of any change to F the procedure as a result of the test results.

OPERATING CONSIDERATIONS

In addition to the normal plant operating procedures and limitations, the following should be observed:

1. C The HRH and MS temperature imbalance between each SG module and the average for the loop should not exceed 30°F (in steady state) or C the limits given in SOP 12-04 whichever are more restrictive. In addition, the maximum individual module MS steady state temperature should be limited to 995°F. The purpose of the 995°F limit is to provide margin on MS temperature when fluctuations occur.

2. Steady state module helium inlet temperature shall be limited to ±45°F about the mean or the limits given in SOP 12-04 whichever are more restrictive.

D 3. In order to minimize the chance of getting into a degraded performance condition during fluctuations, the maximum region outlet gas temperature during steady state conditions shall be limited as follows: From previous fluctuation data, it was noted that the following core regions exhibited the most severe temperature changes during the C fluctuation: Regions 1, 2, 3, 4, 5, 6, 7, 9, 12, 20, 33, 34, 35, B 36, and 37. All of these regions must be kept at least 60°F, 80°F, B or 100°F below the allowable temperature limit of LCO 4.1.7 as shown in Figure 1. All other regions must be kept at least 35°F below the allowable limit.

E NOTE: The margins per Figure 1 are based on cycle 1 experience. When fluctuations are observed in cycle 2, the regions that exhibit the largest temperature variations may be different. As differences, if any, are observed, Figure 1 will be administratively revised accordingly.

G 4. The plant is defined to be in a fluctuation operating mode when G individual nuclear channels exhibit cyclic deviations from the average G power equal to or greater than 0.5% peak-to-peak of full power not G exceeding a 30-minute period.

F 5. Operation and/or testing at power levels >70% should be in accordance D with the B-0 startup test program.

F 6. Throughout the duration of this RT, all plant control systems are to be F in automatic (except for the one test with the reg-rod in manual, see F Step 4C of the Procedure), and with MS and HRH temperature controls set F to a maximum of 980°F.

F Note: The reason for selecting the temperature setpoint at 980°F vs F 1000°F is to allow margin for the temperature swings that F occur when fluctuations develop.

LIMITS DURING FLUCTUATION TESTING

Test Limits

F 1. Proposed testing will be conducted within the Technical Specification F limits.

F 2. Throughout the test, the intent will be to minimize the time spent F in fluctuation except when necessary to record FM data. When fluctu- F ations are present, the following should be observed:

F A temperature fluctuation of module main steam temperature F about its mean of ±10° (20°F total amplitude) is acceptable F with no specific time considerations.

F A temperature fluctuation of module main steam temperature F about its mean greater than ±10°F (20°F total amplitude) but F less than ±30°F (60°F total amplitude) should not exceed one F hour in duration per event.

A temperature fluctuation of module main steam temperature about its mean of $\pm 30^{\circ}F$ ($60^{\circ}F$ total amplitude) is cause to take immediate corrective action by reducing power to stop the fluctuations.

A uni-directional module main steam temperature change of $60^{\circ}F$ (excluding the average component of intentional steam temperature changes) is cause to take immediate corrective action by reducing power to stop the fluctuations.

A module main steam temperature of $1025^{\circ}F$ is cause to take immediate corrective action by reducing power to stop the fluctuation.

A primary coolant activity increase greater than a factor of 25% but less than a factor of 5 over the prior equilibrium value for that power level is cause to take immediate corrective action by reducing power to stop the fluctuations.

3. A limit of $\pm 10\%$ of full power range on any nuclear channel will be maintained.

4. The helium purification system will be in service during all testing.

5. An increase in primary coolant activity levels greater than a factor of five (5) over prior equilibrium values for that power level during any fluctuation test will be cause for terminating the testing and proceeding with an orderly plant shutdown.

Corrective Action

1. If any of the established limits or conditions outlined in items 2 through 4 above are exceeded during a fluctuation test, the test will be terminated, and further plant testing in the fluctuating mode will be suspended until specifically authorized by PSC management.

2. If any of the following conditions are exceeded, immediate action will be taken to terminate the fluctuation test and further testing in fluctuation mode will be suspended until authorization to proceed is obtained from the Commission:

   a) Technical Specification limits are exceeded

   b) An increase in primary coolant activity levels greater than a factor of five (5) over prior equilibrium values for that power level.

   c) A temperature change of module main steam temperature of $150^{\circ}F$ relative to the initial steady state temperature and exclusive of temperature change due to load changes

   d) A module main steam temperature which exceeds $1075^{\circ}F$.

3. If inadvertent fluctuations are observed (see page 6 for the definition of a fluctuation) in normal operation, corrective action will be taken

F F F to terminate the fluctuation, and PSC management authorization will be required prior to returning to a power level that would approach that level that the inadvertent fluctuations were observed.

INSTRUMENTATION/DATA SYSTEMS

Through the duration of this test, the following data systems shall D be operating and personnel should be present for monitoring:

C D C 1. Brush recorders (located in the auxiliary control room) with all steam generator module main steam outlet temperatures and nuclear channels. A data system engineer will be present to monitor the recorders. Both wide range brush recorders (700°F - 1100°F) and either narrow range brush recorders (100°F, zero suppressed) or digital display by the steam generator data acquisition system will be D available to monitor the steam generator module main steam outlet temperatures.

C 2. Data logger (located in the control room). The core performance engineer will be present to monitor the core temperature limiting conditions for operation.

C 3. The primary coolant activity monitor (located in the control room).

D 4. FM data acquisition system.

If any of the above systems becomes inoperable, testing shall be halted until the system is reinstated. If fluctuations are encountered when any of these systems is inoperable, core power should be reduced until the fluctuations cease.

D D D During power increases or pulsed circulator speed changes and for a period of 2 hours (power increase) or 1 hour (circulator speed pulse) following either of these system changes, the following data system and data taking frequencies are desired:

1. Data logger on a fast sample rate (15 seconds or less)

2. Steam generator Fox II computer on a fast sample rate (15 seconds)

3. Model verification computer

4. FM data acquisition system

D 5. Brush recorders

At periods during the test when the initial conditions for a fluctuation test are being established (orifice adjustments, flow/power changes), the following data systems and data taking frequencies are desired.

1. Data logger on a sample rate of 2 minutes or faster

2. Steam generator Fox II computer on a sample rate of 15 seconds or faster

3. Model verification computer

D 4. FM data acquisition system

D 5. Brush recorders

D The traversable thermocouples are to be positioned per RT-524.

PART 1: TESTING AT ≤70% POWER

Initial Conditions

F 1. Plant at approximately 40% power.

2. The orifices are to be adjusted such that the region exit temperatures and steam generator inlet temperatures are reasonably balanced
D per normal procedures and per the Operating Considerations section
D of this RT.

Procedure

D 1. The objective of this test is to develop a core pressure drop vs
D core flow rate (or power) stability threshold line. Thus it is
D desired to initiate fluctuations at three or more values of core
D flow rate. This will be done by orificing the core to different
D flow resistances. Depending on the core flow rate at which fluc-
D tuations are initiated in the first test, higher or lower values
D of core resistance may be selected. To generate a reasonably good
D stability threshold line it is desired to initiate fluctuations at
D a lowest power level of about 40% to 50% and at about every 10%
D increase in power thereafter.

D NOTES: 1. Each time fluctuations are initiated, Data Sheet 1 must
D be completed.
D 2. The most effective means of halting fluctuations is by
D power reduction. Experience has shown that to halt a
D fluctuation the power may have to be reduced by 5% to 10%
D below the power level which produced the fluctuation.
D 3. Wait at least 1/2 hour to reach thermal equilibrium
D prior to performing any fluctuation test, wait 2 hours
D after attempting to initiate a fluctuation by a load
D increase before continuing, wait 1 hour after attempting
D to initiate a fluctuation by a pulse change in circulator
D speed before continuing.

D E D D 2. For the first test configuration, adjust the core orifices in a series of steps using the procedure supplied by the test coordinator as a guide to obtain an average core pressure drop of 2.3 psi. Core resistance corresponding to this core pressure drop and core flow rate may be calculated by:

$$\text{Resistance} = 2.0 \cdot 10^{13} \frac{\Delta P \text{ Measured} \cdot \text{Pressure}}{\text{Flow}^{1.85} \cdot (T_{in} + 460)}$$

where ΔP measured is the measured core pressure drop in psi (item 71 in DF 76)

Pressure is the circulator inlet helium pressure in psi (item 9 in DF 76)

Flow is the total circulator flow in lbm/hr (item 72 in DF 76)

T_{in} is the circulator inlet temperature in degrees Fahrenheit (average of items 1 and 2 in DF 76)

Verify that the region outlet gas temperatures have adequate margin from LCO 4.1.7 per Figure 1 and that the S/G module temperatures are within the Operating Limits Section of this RT before preceeding.

D D D D 3. Begin a series of power rises by increasing turbine load at 3% per minute in incremental load changes of 3% (~9 MWe). Continue the incremental load increases until fluctuations develop or a plant limit is reached. Prior to each incremental load increase, adjust orifices as necessary to balance region outlet gas temperatures and module inlet gas temperatures. In addition, adjust the reg-rod position according to normal operations practice.

D 4. When fluctuations develop, there are three basic sets of data to obtain:

A. It is desirable to obtain FM data during the onset of all fluctuations.

B. For one fluctuation with each core flow resistance, obtain FM data for one hour during the fluctuations. The operating limits stated in this RT must be adhered to during the one-hour period.

F F E C. For one of the fluctuations described in Step 4B, it is desirable to obtain FM data for an additional 1/2 hour, with the reg-rod disabled and all rods held in a constant position. Attachment I defines the procedure for disabling the reg-rod. The operating limits stated in this RT must be adhered to during fluctuations.

G G G G G For one of the fluctuations described in Step 4B, it is desirable to obtain FM data for an additional 1/2 hour with the steam generator module trim valves in manual control -- (in a fixed position). During this fluctuation period, the operating limits stated in this RT must be adhered to. At the end of this 1/2 hour the trim valves will be returned to manual control.

C C The Core Performance Engineer will coordinate which particular fluctuations will be monitored per items B and C above.

5. For each fluctuation encountered, repeat the step preceding the fluctuation and, if fluctuations are not encountered, that step which caused the fluctuation. For example, if fluctuations are encountered during a power rise from 50% to 53% power, return to 47% power and repeat the 47% to 50% power rise. If no fluctuations occur, then repeat the 50% to 53% power rise.

6. When a fluctuation threshold has been defined per steps 2 - 4, return to the highest power level for which a fluctuation was not initiated (47% in the above example). Perform Part II of RT-499, the circulator speed pulse test, where the primary coolant flow is increased by ~3%, held at the higher value for a short duration (~10 seconds) and returned to its initial level. If fluctuations are not initiated, increase power by 3% at 1/2%/minute and repeat Part II of RT-499, the circulator speed pulse test. Continue until fluctuations are encountered or until a power level 9% above the maximum from step 4 is achieved (until 62% in the above example).

7. Repeat the circulator speed pulse test (Part II of RT-499) for the step preceding the fluctuation and, if fluctuations are not encountered, that step which caused the fluctuation.

8. The next test power level depends on the power level at which fluctuations were encountered in Step 5 above. The objective is to initiate fluctuations at power levels approximately 10% apart; that is, at about 40%, 50%, 60% and 70% power. For the selected new power level the next value of core resistance can be calculated from the conditions which initiated the preceding fluctuation as follows:

$$R_{NEW} = R_{OLD}\left(\frac{F_{OLD}}{F_{NEW}}\right)^2$$

where R_{OLD} is the resistance from the preceding test

F_{OLD} is the core flow rate from the preceding test (step 5)

F_{NEW} is the flow rate corresponding to the power level where the next fluctuation is desired.

9. The starting point for the next test is with the core orificed to achieve the new core resistance, R_{NEW}, per the equation given in step 2, and with a core pressure drop 10% - 20% below that at which the preceding fluctuation was initiated. In getting to the new starting point, it is desired to keep the core pressure drop at or below the value at which the fluctuation test will be started to prevent inadvertent fluctuations. To do this it is suggested that:

A. If $R_{NEW} > R_{OLD}$, reduce flow before closing orifices.

B. If $R_{NEW} < R_{OLD}$, open orifices before increasing flow

D 10. Repeat steps 3 - 7 to obtain data for at least 3 values of core resistance. To generate a reasonably accurate stability threshold, fluctuations should be initiated at a lowest power level of about 40 - 50% and at increments of ~10% power above this initial level.

D Depending upon the effect of refueling on the fluctuation threshold, it may be necessary to vary attemperation flow (core P/F), region outlet temperature mismatches, or partially insert control rods (power flattening) in order to demonstrate the threshold at high power levels. Any or all of these operations may be used as permitted by SOPs and Technical Specifications. Caution should be exercised to maintain the region temperature margins for L.C.O. 4.1.7 given in Figure 1 and to not violate the core thermal safety limit on core power/flow ratio (S.L. 3.1, Figure 3.1-2).

D If the pulse change in circulator speed test fails as a "trigger" for fluctuations for two values of core resistance, then it is not necessary to continue attempting to initiate fluctuations via this mechanism.

D Part 2: Testing at >70% Power

D From an initial steady-state condition of ~70% power, the core power will be increased slowly (1/2% per minute) to ~73% and stabilized. If no fluctuations occur, power will be reduced to 70%, stable operation achieved, and a pulse change in circulator speed will be employed to attempt to initiate fluctuations. If fluctuations do not develop, a 3% load increase at 3% per minute will be effected to attempt to trigger fluctuations. This process of slow power increases, circulator speed pulses, and then rapid power increases of 3% will be continued until fluctuations are encountered or until 100% power or a plant limit is encountered. If fluctuations occur, data will be recorded for a short period of time and the step which initiated the fluctuation will be repeated to establish reproducibility of the onset of fluctuations.

D Initial Conditions

F 1. Plant at approximately 70% power.

D 2. The orifices are to be adjusted such that the region exit temperatures and steam generator inlet temperatures are reasonably balanced per normal procedures and per the Operating Considerations section of this RT.

D Procedure

D 1. The objective of this test is to extend the core pressure drop vs core flow rate (or power) stability threshold line developed in Part 1.

D NOTES: 1. Prior to each incremental load increase, adjust orifices as necessary to balance region outlet gas temperatures and module gas temperatures. In addition, adjust the reg-rod position according to normal operations practice.

D 2. The most effective means of halting a fluctuation is by
D power reduction. Experience has shown that to halt a
D fluctuation the power may have to be reduced to 5% to 10%
D below the power level which produced the fluctuation.
D 3. Each time a fluctuation is initiated, Data Sheet 1 must
D be completed.
D 4. Wait at least 1/2 hour to reach thermal equilibrium
D prior to performing any fluctuation test, wait 2 hours
D after attempting to initiate a fluctuation by a load
D increase before continuing, wait 1 hour after attempting
D to initiate a fluctuation by a pulse change in circulator
D speed before continuing.

D 2. For the first test configuration, adjust the core orifices in a series
E of steps using the procedure supplied by the test coordinator as a guide
D to obtain an average core pressure drop at least 10% below the threshold
D ΔP determined in Part 1 for 70% power. The core resistance corresponding
D to this core pressure drop and core flow rate may be calculated by the
D equation given in Part 1 procedure step 2.

D If the core orifices are opened as much as possible, the main steam tem-
D perature may be reduced to 40°F below the reheat temperature setpoint,
D core control rods may be partially inserted (to flatten the power distri-
D bution and thereby permit further opening of orifices), or attemperation
D flow may be increased within the limits of SOPs and Technical Specifications
D to further reduce the core pressure drop.

D Verify that the region outlet gas temperatures have adequate margin
D from LCO 4.1.7 per Figure 1 and that the S/G module temperatures are
D within the Operating Limits Section of this RT before proceeding to
D the next orifice changes.

D 3. Increase power by ~3% (~9 MWe) at 1/2% per minute. If fluctuations
D do develop, go to step 6. If fluctuations are not initiated, decrease
D power by ~3% to achieve initial conditions once again.

D 4. Perform Part II of RT-499, the circulator speed pulse test, where the
D primary coolant flow is increased by ~3%, held at the higher value for
D a short duration (~10 seconds) and returned to its initial level. If
D fluctuations develop, go to step 6.

D 5. If fluctuations are not initiated by step 4, increase power by 3% at
D 3% per minute. If fluctuations develop, go to step 6. If fluctuations
D do not develop, repeat steps 3 through 5 starting at the new power level
D (~3% above the preceding power level). Continue with successively higher
D power levels until fluctuations do develop or until 100% power or a
D plant limit is encountered.

D 6. When fluctuations develop, there are two basic sets of data to obtain:

D A. It is desirable to obtain FM data during the onset of all fluctuations.

D B. For one fluctuation with each core flow resistance, obtain FM
D data for one hour during the fluctuations. The operating limits
D stated in this RT must be adhered to during the one-hour period.

The Core Performance Engineer will coordinate which particular fluctuations will be monitored per item 8 above.

7. For each fluctuation encountered, repeat the step (load increase or circulator speed pulse change) preceding the fluctuation and if no fluctuations occur, that step which caused the fluctuation. For example, if fluctuations are encountered during a power rise from 73% to 76% power, return to 70% power and repeat the 70% to 73% power rise, then if no fluctuations occur, repeat the 73% to 76% power rise.

Similarly, if the circulator speed pulse changes initiated fluctuations, then repeat the circulator speed pulse test (Part II of RT-499) for the step preceding the fluctuation and that step which caused the fluctuation.

8. After demonstrating repeatability, reduce power and re-establish a stable plant configuration. If fluctuations were first initiated by the 1/2% per minute load increase (step 3), then establish the initial conditions preceding initiation of fluctuations and perform the circulator speed pulse test, step 4. If fluctuations were first initiated by the pulse change in circulator speed (step 4), then establish initial conditions preceding initiation of fluctuations and effect a 3% load increase at 3% per minute, i.e., step 5. If fluctuations were first initiated by the 3% per minute load increase (step 5), proceed to step 9.

9. The next starting point is with a primary flow rate (power level) 5% - 10% above that of the preceding starting point but with the same core pressure drop. This may be achieved as before, by opening the orifices to a new value of core resistance.

Partial rod insertion may be employed to permit further opening of orifices and/or the main steam temperature set point may be reduced to 40°F below the reheat temperature setpoint to reduce core pressure drop.

To guard against inadvertent fluctuations, the orifices should be opened before increasing flow.

10. Repeat steps 3 - 5, at successively higher power levels, until 100% power is reached or until a plant limit is encountered.

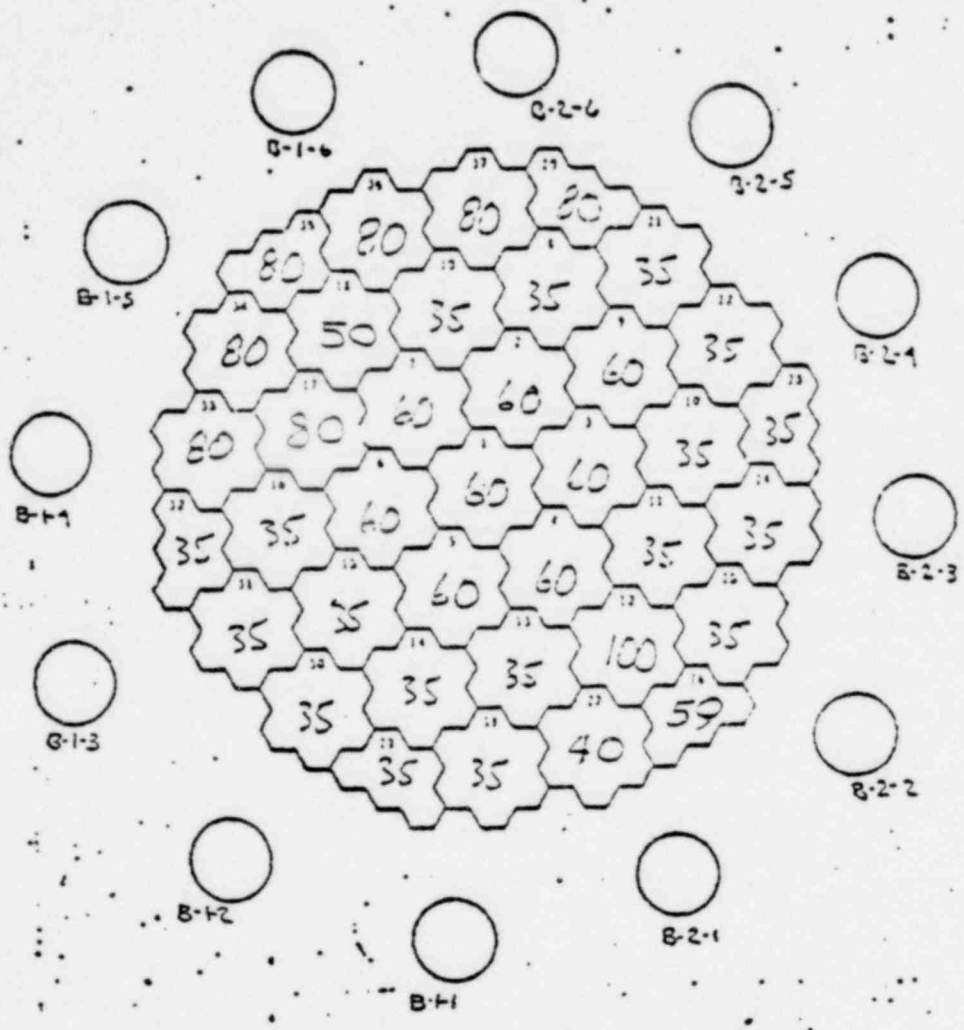

FIG. 1. REQUIRED MARGIN ON ALLOWABLE MISMATCH
(L.C.O. 4.1.7 LIMIT - TEST)

(new figure in Revision B)

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ATTACHMENT I

REG-ROD INFLUENCE TEST

D D D D D The purpose of this test is to determine if taking the reg-rod out of auto will reduce the amplitude of the fluctuations and to obtain data from the out-of-core and in-core nuclear channels which are responding to the influence of the fluctuation phenomenon alone, without the complicating effect of reg rod motion influencing the signals. The procedure is as follows:

1. After a fluctuation has developed, monitor the amplitude of the module MS temperature fluctuation to verify that the Operating Limits of this RT are met. Previous experience with fluctuations indicates that the amplitude may be reduced by slowly reducing power and thus allow a longer time in fluctuations.

2. Disable the ability of the flux controller to move the reg-rod by placing the reheat temperature controller in manual and then rotating the regulating rod selector switch (HS-1218) to the OFF position. This permits the automatic flux control to initiate a rod runback if needed as a result of any transient during this test. If necessary, manually position the reg-rod to the average position that existed prior to disabling the automatic control feature. This step is desirable in order to maintain a constant value for total reactor power and average core temperature.

   CAUTION: If a runback occurs, the reheat temperature controller should be nulled out and returned to automatic and HS-1218 returned to the #1 position as soon as possible.

D 3. Wait a period of approximately 30 minutes to determine the effect on fluctuations. Control room trend recorders and brush recorders are to be used for this purpose. Return the reg-rod to auto by returning HS-1218 to the #1 position, null out reheat temperature controller, and return it to automatic.

DATA SHEET I

Complete this data sheet if fluctuations were encountered. This data sheet is to certify that test limits were not exceeded.

A. If any of the following limits are exceeded, testing must be stopped until further authorized by PSC Management.

	Limit
1. Were OPERATING CONSIDERATIONS 1,2&3 met? YES___/NO___	N/A
2. Time/Date fluctuation started _____	N/A
3. Power Level at start of fluctuation _____	N/A
4. Time/Date power reduced _____	1 hour
5. Time/Date fluctuation stopped _____	N/A
6. Power Level when fluctuation stopped _____	N/A
7. Maximum fluctuation on Nuclear Channel # _____	N/A
Peak Magnitude _____	±10% (< 70%) ±20% (>70%)
8. Maximum fluctuation of Loop I MS Temp Module #_____	N/A
Fluctuation Magnitude _____	60°F P-P
Hottest Module # _____ _____°F	1025°F
9. Maximum Fluctuation of Loop II MS Temp Module # _____	N/A
Fluctuation Magnitude _____	60°F P-P
Hottest Module # _____ _____°F	1025°F
10. Equilibrium Value of Primary Coolant Activity for power level of test _____	N/A
11. Maximum Value of Primary Coolant Activity During test _____	25% increase Required for Testing
12. Were Data Systems in service? YES_____/NO_____	
13. Was a purification train in service? YES___/NO__	Required for Testing

B. For any of the following, testing must be stopped and reported to the NRC:

1. Any Technical Specification exceeded? YES_____/ NO_____
2. Any MS Temperature Fluctuation > 150°? YES____/ NO_____
3. Primary Coolant Activity >5 times normal? YES_____/ NO_____
   This requires an immediate orderly shutdown.

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PSC SHIFT SUPERVISOR _____
Signature/Date

TEST COORDINATOR _____
Signature/Date