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AUTH. NAME AUTHOR AFFILIATION
OXSEN, A. L. Washington Public Power Supply System
RECIP. NAME RECIPIENT AFFILIATION
MARTIN, J. B. Region 5 (Post 820201)

SUBJECT: Forwards response to 920815 confirmatory action ltr re 920815 power oscillation event. Approx 80 s elapsed between beginning of oscillation event & manual scram All quarantine records will be available for NRC review.

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

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August 29, 1992
G02-92-205

Docket No. 50-397

Mr. J. B. Martin
Regional Administrator
U. S. Nuclear Regulatory Commission
Region V
1450 Maria Lane
Walnut Creek, CA 94596

Dear Mr. Martin:

Subject: **WNP-2, OPERATING LICENSE NPF-21**
RESPONSE TO CONFIRMATORY ACTION LETTER

Reference: Letter dated August 15, 1992, J. B. Martin (NRC) to A. L. Oxsen (SS), "Confirmatory Action Letter"

The purpose of this letter is to provide the Supply System's response to the Confirmatory Action Letter (CAL) regarding the power oscillation event that occurred on August 15, 1992. The CAL listed the actions we committed to take prior to restarting the WNP-2 facility. We also understand that the list was not necessarily inclusive of all actions required prior to restart.

On the morning of August 15, 1992, WNP-2 was being returned to power after a temporary power reduction to facilitate a drywell entry. The Reactor Recirculation (RRC) pumps were at slow speed and preparations were being made to shift the RRC pumps to fast speed. In order to shift the pumps, each RRC pump flow control valve (FCV) must be taken to closed (minimum) position. The FCV for the A RRC pump had been closed, and an LPRM down scale alarm was received. The operating crew immediately verified oscillations in APRM indications and in core flow.. As required by plant procedures, a manual scram was initiated. Approximately 80 seconds elapsed from the beginning of the oscillation event (prior to any alarms received in the control room) to the manual scram. Although the total core power change was less than 1%, APRMs indicated a peak-to-peak oscillation of 22% power.

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The following is a discussion of the commitments outlined in the CAL and Supply System actions taken to satisfy those requirements.

1) Quarantine records and available plant operations data for review by NRC personnel.

   All records and available plant operations data were immediately quarantined. This material, as well as other information related to the event, was provided to the Augmented Inspection Team (AIT), led by Mr. L.F. Miller, upon their arrival at the site on August 17, 1992. The AIT met extensively with Supply System and vendor personnel. Additionally, this team has reviewed plant data. It is our understanding that all requests for access to data, assessments and explanations of the data were provided in a timely and accurate manner to the satisfaction of the AIT throughout the investigation.

2) Develop a plan for investigating the August 15, 1992 Unusual Event, conduct a thorough investigation, and obtain a full understanding of that event.

   Immediately following the event, the Supply System assembled a team to investigate the event, develop a full understanding of the cause or causes, and develop a corrective action plan. The team functioned under the direction of Mr. C.M. Powers, Director of Engineering and included, in addition to cognizant Supply System personnel, representatives of Siemens Power Company (reload fuel supplier for WNP-2), General Electric Company (NSSS vendor) and INPO. This team performed a root cause analysis investigation, in accordance with the methods and techniques described in plant procedures. The purpose of this analysis was to identify the cause of the event, any contributing factors, and to assess the effectiveness of our current core stability requirements. (The current stability requirements can be summarized as methods used to detect and suppress power oscillations.) The primary root cause of the event can be summarized as the unanticipated interaction of operating conditions and components, in that Supply System staff and vendor personnel failed to identify the extent of the tendency for this core design to become unstable under certain operating practices. The plan and the detailed results of this investigation are contained in the Root Cause Executive Summary, Attachment 1 to this letter.

3) Define pre-restart and post-restart corrective actions identified as a result of this event.

   An operating strategy for Cycle 8 (the current cycle) has been developed as a short-term corrective action. A specific start up plan, including operating constraints and start up rod patterns, has been developed and discussed with the AIT. This plan (dated August 29, 1992) will be followed for the initial start up from this event. The plan will also be

used for any future start up during this fuel cycle, with modifications based on core burn up. Any significant change from the method or the operating constraints in this plan will be discussed with the NRC prior to its use. Additionally, long-term issues have been identified and prioritized. The Root Cause Executive Summary contains a detailed description of the corrective actions to be taken by the Supply System and the proposed schedule for the implementation of those activities. Included in those activities are: 1) development and implementation of additional surveillance testing to assure operability of the core stability monitor; 2) evaluations of actions which can be taken to improve the reliability and human interface of the core stability monitor; and 3) further verification and benchmarking of the fuel vendor's core stability computer code.

4) Discuss with the NRC the results of the investigation prior to restart.

Discussions with the AIT have been ongoing throughout the investigation. A presentation was made to the NRC on August 20, 1992. The initial exit meeting with the AIT was held on August 21, 1992. The Supply System presented proposed corrective actions during these meetings and will implement the short-term actions prior to startup. This involves procedure revisions and personnel training. The details of these actions are discussed further in Attachment 1. Further, we will notify the WNP-2 NRC Resident Inspector in the event that we find it necessary to reduce power to twenty-five percent to stay within the start up constraints.

The Supply System Team has conducted a thorough investigation of the causes and contributing factors for the power oscillation event at WNP-2. We are confident that the operating strategy developed and the corrective actions taken will provide reasonable assurance that this or a similar event will not reoccur. Consultation with the industry, INPO, and vendors has provided valuable information to all of the parties involved. Based on the results of our investigation, the corrective actions to be taken prior to startup, and the commitments made, the Supply System has determined the WNP-2 facility can be restarted and operated safely. This conclusion has been endorsed by the WNP-2 Plant Operations Committee and the Corporate Nuclear Safety Review Board.

Sincerely,

A. L. Oxsen,
Acting Managing Director

MGE/bk
Attachment

cc: Docket Control Desk
NS Reynolds - Winston & Strawn
RR Assa - NRC
DL Williams - BPA/399
NRC Site Inspector - 901A

ATTACHMENT 1

ROOT CAUSE ANALYSIS SUMMARY SHEET

Power Oscillation Event August 15, 1992

EXECUTIVE SUMMARY

1.0 BRIEF DESCRIPTION:

On August 15, 1992, at 0300 hours the plant was manually scrammed due to observed power instabilities with APRM oscillations greater than 10%. This was done in accordance with PPM 4.12.1.7, "Unintentional Entry into Core Instability Region". The event occurred when Recirculation Flow Control Valve RRC-FCV-60A was closed in preparation for Recirculation pump 'A' RRC-P-1A upshift. Plant systems responded normally to the scram and shutdown was continued to a "cold shutdown" condition. An Unusual Event (UE) was declared and EOP 5.1.1 "RPV Level, Pressure, and Power Control", was entered on Reactor water level reaching +13 inches.

The pertinent sequence of events leading up to this power oscillation event were as follows (see attached Event and Causal Factor Chart). The unit was reduced in power from 100% to about 5% power starting at 1855 hours on August 13, 1992. This was due to unidentified drywell leakage of 5 GPM, in accordance with TSAS 3.4.3.2.b. This was to allow a drywell entry to locate and isolate the source of the leak. The leak was located on RWCU-V-103 as a failed packing and the valve was back seated to stop the leakage.

At 1710 hours on August 14, 1992, the operators commenced returning the unit to 100% with rod pulls. This is approximately (22) hours after 100% power operations which would put the core about 10-12 hours after Xenon peak from the down power maneuver. This level of Xenon is still significantly higher than 100% equilibrium Xenon levels as well as equilibrium values for 5-7% power, where the rod pull was initiated. The unit was held at 34% power and 30% flow for Turbine Bypass Valve testing and Control Rod Drive timing from 2355 hours on August 14, 1992 to 0258 hours on August 15, 1992. At 0258 hours, the control room operators commenced closing RRC-FCV-60A in preparation for

recirculation pump 1A shift to 60 Hz speed. At 02:59:49 hours rod out block alarms and LPRM down scale alarms were received. The operators noted that the APRMs were oscillating between 25% and 45% power. The Shift Manager directed a Manual Scram in accordance with PPM 4.12.4.7 "Unintentional Entry in Core Instability Region", at 03:00:40 hours. The shutdown of the unit to a cold shutdown condition went normally, with no noteworthy events outside the bounds of procedures.

Immediately, an Incident Investigation Team was formed with a variety of team members from Supply System staff, General Electric, Siemens Power Corporation, and INPO (see attached letter dated August 15, 1992). The group's efforts to define the scope of their task resulted in a Fault Tree Analysis Plan to systematically define all possible sequences of events pertaining to power oscillations and investigate each one of these sequences thoroughly (see attached Fault Tree Analysis).

2.0 FINDINGS:

The findings of this team were that the Core Spatial Effects and Fuel Assembly Design, together with the radial and axial flux profiles established in the core, combined to cause a higher probability of power oscillations than that projected by the regions in the WNP-2 Power to Flow Map (see attached Power to Flow Map). Specifically, the 9x9 bundles in the core have a greater thermal-hydraulic pressure drop across them as compared to the 8x8 design. Currently, for Cycle 8, WNP-2 has about 20% of its core with 9x9 design and the remaining 80% of the core is 8x8 design with 12 LFAs. The rod pattern selected had the 9x9 assemblies in uncontrolled cells and the 8x8 bundles in controlled cells. This allowed the 9x9 fuel to be operating at higher power levels than the 8x8 fuel and at significantly reduced flow due to 1) higher pressure drop across the 9x9 bundle, and 2) higher power level per bundle causing increased flow resistance. As can be seen from the attached information (See attached Power Flow-Individual Assemblies) a significant number of 9x9 assemblies were operating in the high power, low flow region of the Power to Flow Map. This is the prohibited region as defined by the BWR's Owners Group (BWROG) and requires an immediate scram if the overall core is found to be operating in this region.

The above explanation describes the conditions which placed the core in the region of the Power to Flow Map that would increase the probability of a power oscillation. The events which led the STA and operators to place the core in this condition are as follows. The Xenon transient allowed the STA to proceed further into the "Pull Sheet" where the

shaping rods were fully withdrawn from the core. Also, it allowed the STA to set the radial and axial core flux profile for conditions after the pump shift, but these same conditions were not beneficial for prevention of power oscillations. Specifically, the Nuclear Engineer set a radial flux profile with a Critical Power Ratio (CPR) of 1.728 with a limit of 1.80 giving a Fraction of CPR of .953 for bundle 35-36. The Total Peaking Factor (TPF) was 3.782 for location 35-26-3. The time these values were calculated for was 0257, 3 minutes before the power oscillations. The BWROG guidelines indicate that these factors may be contributors to power oscillations when in low flow and high power conditions. Another potential transient for power oscillations is feedwater temperature. In this case, the WNP-2's feedwater temperature was constant at 310°F and 311°F, which is normal for this power level. The time (4 hours) spent at relatively high power and low flow (i.e., 34% power, 30% flow) for CRD timing and bypass valve testing increased the chances of a power oscillation event occurring from known challenges to stability such as inlet subcooling transients.

3.0 <u>ROOT CAUSE:</u>

This event was analyzed by Plant staff with representatives from General Electric, INPO and Siemens Power Corporation (Fuel Vendor). The conclusion of this team is that this event had several contributing conditions/failure mechanisms which were:

- The 9x9 fuel bundles have a measurable difference in flow under the same pressure differential, as compared with 8x8 fuel. Also the 9x9 fuel assemblies were being required to operate at a higher power. These conditions led the core to be susceptible to power oscillations.

- The radial and axial peaking factor established for the core increased the probability of power oscillation. Principally, the radial peaking factor caused the 9x9 fuel to be driven at higher power levels than the 8x8 bundles in the core. This radial peaking factor was influenced by the amount of Xenon in the core. With the large Xenon concentration in the core, it allowed the plant to establish a flux profile which resulted in a significant fraction of the 9x9, and even some of the 8x8, fuel bundles operating with relatively high power and lower flow conditions than the remaining bundles in the core.

Therefore, the primary **Root Cause** for this event has been determined to be:

Unanticipated Interaction of Operating Conditions and Components

in that Supply System staff and vendor personnel failed to identify the extent of the tendency for this core design to become unstable under certain operating practices.

1. The fuel designer did not/was not asked to perform sensitivity analyses for core instability at reactor conditions other than those required to perform reload licensing analyses.

    a. Current licensing methodologies do not require these sensitivity analysis on start up power distributions.

    b. Computer models to analyze cores to this level of sophistication are in development and not licensed for use.

    c. The designer believed the hydraulic differences between 8x8 and advanced 9x9 would not contribute to the likelihood of instability under nominal start up conditions.

Root Cause: **Analysis Deficiencies**

2. The Supply System design verification process for the mixed core consisting of 9x9 and 8x8 fuel assemblies failed to discern the impact the differences in hydraulic resistance of the fuel assemblies would have on the core's susceptibility to instabilities outside existing instability regions defined per current BWROG guidance.

    a. Design verification included assurances of conformance to license requirements, but did not discern that core stability licensing analyses did not consider the effects of high radial peaking on core stability at operating conditions which existed at conditions other than the licensing basis.

Root Cause: **Inadequate Independent Review of Design Change**

3. The Reactor Engineers selected a start up rod pattern with characteristics of aggressive critical power ratios and high radial peaking which did not consider, in depth, the effects that these patterns could have on core stability predicated on the differences in hydraulic loss coefficients.

   a. Past start ups and operating regimes had not disclosed problems with similar patterns.

   b. The plant stability monitor (ANNA) was not employed to provide early warning of the potential changes in core instability regions during start ups following the refueling outage. This was, in part, due to past experience and a confirmation that the existing core exclusion region versus actual and planned plant conditions for this start up were acceptable.

Root Cause: **Effects of Changing Operating Parameters Not Fully Evaluated**

4.0 CONTRIBUTING CAUSES

Management methods did not permit timely response to known problems in that the BWROG Implementation Guidance for Stability Interim Corrective Actions were not implemented into Plant procedures and methods allowed considerable flexibility to setting rod patterns by the Nuclear Engineer and STA.

1. Although training of STA and Operators did occur in a timely manner, procedural updates were not accomplished to reinforce the training.

2. Plant procedures requiring a start up plan were not strengthened to avoid aggressive radial and axial power distributions which could impact core stability.

5.0 SHORT-TERM CORRECTIVE ACTIONS:

The following is a listing of the short-term corrective actions that will be completed for Cycle 8.

1. In order to maintain assembly power to flow ratio as low as possible, as well as maintaining radial peaking as low as possible, procedures will be implemented to maintain Critical Power Ratio (CPR) greater than 2.2. Core total peaking factor will be maintained less than 3.4 overall by applicable procedures. These are initial parametric values and will be re-evaluated at each cycle during the transition core for validation.

Twelve case studies were run by the Fuel Vendor to validate the stability of the Cycle 8 core (see attached Stability Analysis). This was accomplished utilizing one dimensional and three dimensional modeling codes. As can be seen from the description, the calculations were performed under a variety of conditions including but not limited to: August 15, 1992 restart conditions, August 2, 1992 restart conditions before and after FCV closure, restart conditions with worst case under corrective action restraints both now and at 1000 MWd/MTU, restart conditions with expected plant parameters under corrective action restraints.

The results of these stability analysis show decay ratios for this core to be less than 1.00 in all cases with margins to this value of 0.2 to 0.6 indicating all situations to be self dampening.

2. In an effort to minimize the inlet sub-cooling, which can contribute to power oscillations, a procedural change will require verification of the Minimum Feedwater Temperature Curve (see attached) in PPM 3.1.2 "Power Maneuvering" to minimize power oscillations.

3. Core system for monitoring power oscillations will require that the ANNA system be in service from greater than 25% reactor power and less than 50% core flow (see attached Power to Flow Map). Consistent with operating the ANNA system, a verification by surveillances of ANNA will be performed to assure operability.

4. In addition to general precautions recommended by the BWROG on stability, specific requirements will be in place to minimize plant testing and time spent below 50% core rated flow and above 30% core rated power. This will require shifting recirculation pumps from 15Hz to 60Hz speed at power less than 33%.

5. Establish an approved startup plan that controls and specifies specific rod patterns for Cycle 8 startups. This plan will achieve a rod pattern that has been analyzed for stability prior to closing the first flow control valve for recirculation pump shift to fast speed. Revisions, except for minor rod position deviations due to instrument or equipment malfunctions, will require a new stability evaluation of the alternate rod pattern and Plant Operating Committee approval prior to recirculation pump upshift.

These actions were implemented by procedural changes and training of personnel on these changes. The Power to Flow Map was revised to reflect these changes by designating an "INCREASED AWARENESS" region (see attached Power to Flow Map). BWROG Implementation Guidance for Stability Interim Corrective Actions have been implemented in Plant procedures and reinforced by training sessions and exam testing.

LONG-TERM CORRECTIVE ACTIONS

Long-term corrective actions address the design process and the reviews by Supply System personnel to validate fuel vendor's calculations to ensure stability regions are avoided throughout core cycles. Additionally, verification of the fuel vendor's analysis to support design reviews for future cycles will be performed.

DESIGN PROCESS ACTIONS

An important aspect of the development of the long-term corrective actions and the assignment of priority to each activity was in the determination of the implications on the design process and the operating strategies. Although the WNP-2 Cycle 8 core met the required reload design criteria, the power oscillation occurred outside of the currently identified region of instability. It has become apparent that a core reload design could satisfy all of the regulatory requirements and still allow undesirable operational situations. The Supply System has concluded that, as a long-term corrective action, it will be necessary to supplement our review of the design process. Because the root cause identified problems with operating strategies, the design process and the review of those designs must address those strategies. Additionally, the Supply System recognizes the importance of continued involvement with the industry in the resolution of the core stability issues.

The following is a summary of the changes to be evaluated in order to supplement the existing design process.

EXPAND CORE DESIGN REVIEWS

The scope of the Supply System design verification reviews will be expanded to provide additional oversight of vendor reload design and analysis. This expanded review process will be implemented for the Cycle 9 reload design and will include increased scope and technical depth of the design. A plan for the design verification for Cycle 9 will be developed by March 1993 and the enhanced reviews will include:

- o increased emphasis on the operating performance of the core in addition to meeting the licensing requirements;
- o increased awareness of the impact of core and fuel design changes on plant operations;

- o increased attention to core stability and thermal hydraulic characteristics.

- o fuel vendor will be required to perform additional stability analysis beyond the current licensing requirements.

FUEL DESIGN CRITERIA

The Supply System will evaluate the feasibility of changing the fuel design to one that is more stable than the current 9x9-9X design. The long-term objective is the use of fuel designs which create known and manageable stability characteristics during plant operations and transients. The goal is that the next fuel fabrication contract, for fuel to be delivered in 1995, will meet the criteria necessary to satisfy this objective. The potential of earlier changes in fuel design will be evaluated, but to assure understanding of the impacts of a new fuel design on the existing mixed core, the Supply System does not expect to be able to implement fuel design changes prior to the 1995 fuel delivery.

CORE STABILITY ANALYSIS

To support the enhanced reload design reviews and implementation of operating strategies, the Supply System will pursue obtaining core stability analysis codes. The Supply System will evaluate the existing codes and their availability in an attempt to implement their use in support of Cycle 10 core design verification.

The fuel vendor will accelerate the validation of the present stability code used for assessing selected rod patterns for the startup plan.

CYCLE 8 DESIGN REVIEW

The stability of the existing core will be evaluated at selected exposures to confirm the corrective actions remain valid for the remainder of Cycle 8. Although the analysis for the next exposure increase of 1000 MWD/Mtu has been completed, the review of the rest of the cycle will not be completed prior to restart.

OTHER EVALUATIONS

Beyond those issues directly related to core design and operating strategies, the Supply System identified some contributing factors that require further evaluation.

TECHNICAL SPECIFICATIONS

The frequency specified for the surveillance requirement for power distribution limits and the determination of the "T" factor for APRM set points is condition-based and leads to some confusion. The Supply System will pursue a Technical Specification change to eliminate the confusion and to eliminate the requirement for calculating "T".

STABILITY MONITORING

A short-term corrective action involves splitting signals for the LPRMs input into ANNA, the stability monitoring program. This implementation approach associated with the modification decreased the flexibility of ANNA. The Supply System will evaluate the impact of this reduction in flexibility. One of the options being considered is the modification of the LPRM filters on the input to the process computer and to ANNA. The Supply System will also continue involvement with the BWROG Working Groups for Hardware Design and ATWS/Stability.

A reliability improvement evaluation will be performed to assure the availability and accuracy of the core stability monitor. This investigation will include assessment of power supply, CPU redundancy, auto alarm features, and enhanced surveillance techniques to verify continued accuracy of hardware and codes to replicate decay ratios and amplitudes to known standards.

STATION NUCLEAR ENGINEERING

The Reactor Engineering Group within the Plant Technical Department provides on-shift direction to the operating crews during power operation and maneuvering. The Fuels Engineering Group, within Engineering, is the primary interface with the fuel vendor. The Supply System will evaluate this division of responsibilities and the working relationship between the two groups in establishing strategies during start up and full power operation.

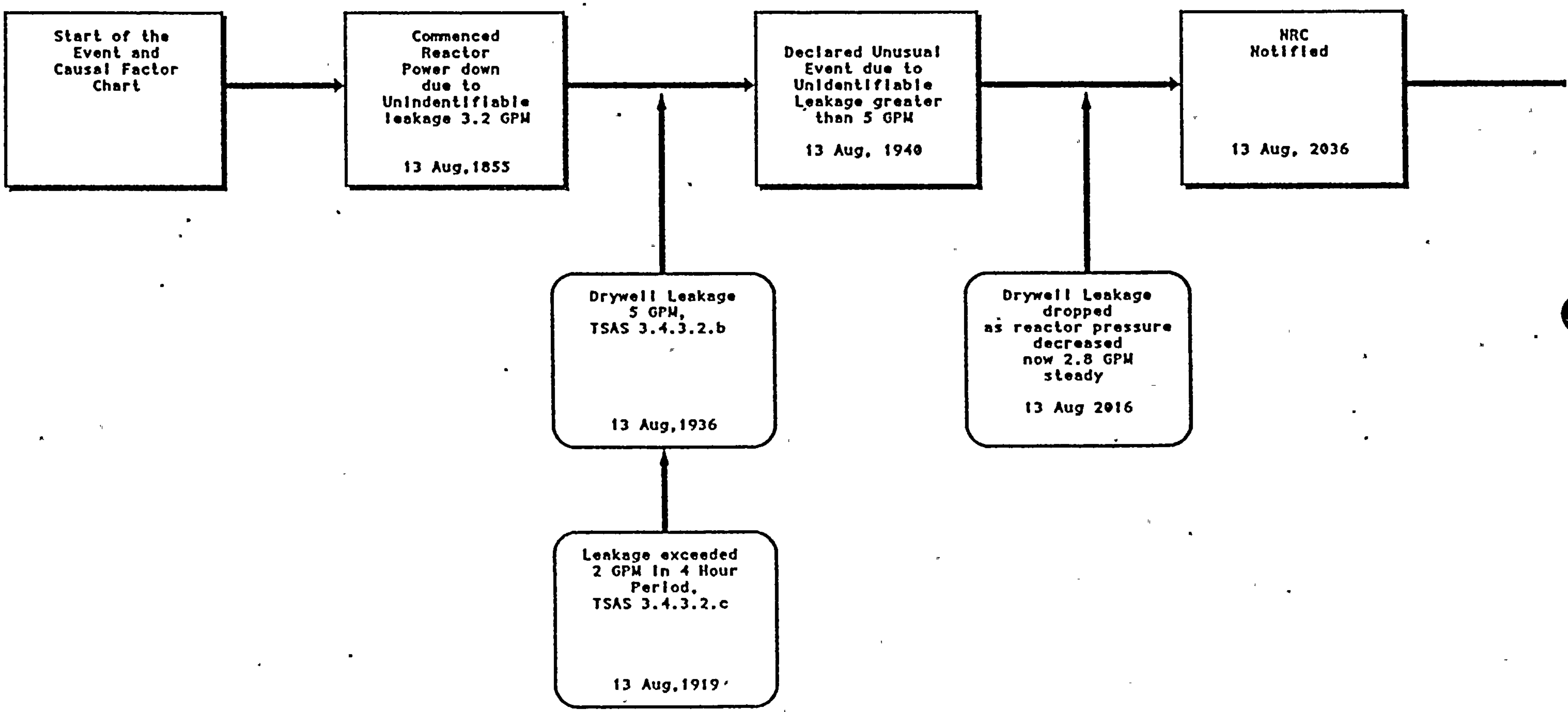
OPERATING STRATEGIES

The Supply System will continue to evaluate the appropriateness of the operating strategies implemented as short-term corrective actions. The actions taken will be considered during the evaluations that will be made during the implementation of the long-term actions. These results may identify changes needed in the operating strategies initially established.

PLANT MODIFICATIONS

Replace FCVs and two speed pump operation with adjustable speed drive (ASD) pumps. This will eliminate the need to conduct operations under the restrictions on FCVs and 15 Hz speed pumps. The current two speed recirculation pumps will be powered from adjustable speed power supplies, allowing continuous flow adjustments from 15 to 60 Hz. With this modification, recirculation flow control valves are not required and will be removed.

Reactor Power Oscillations
15 August 1992



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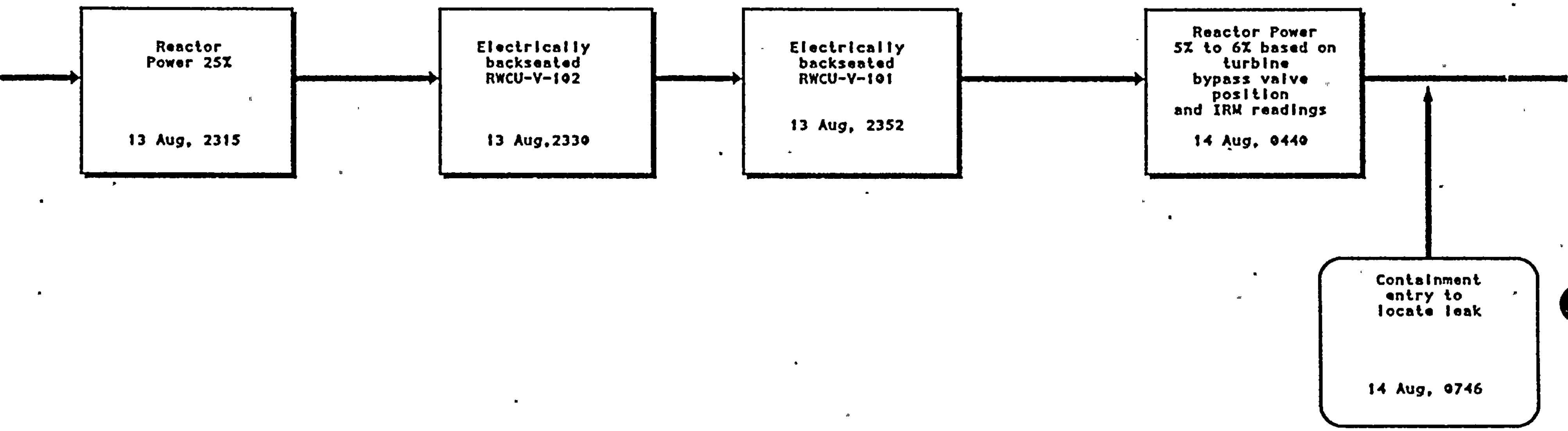

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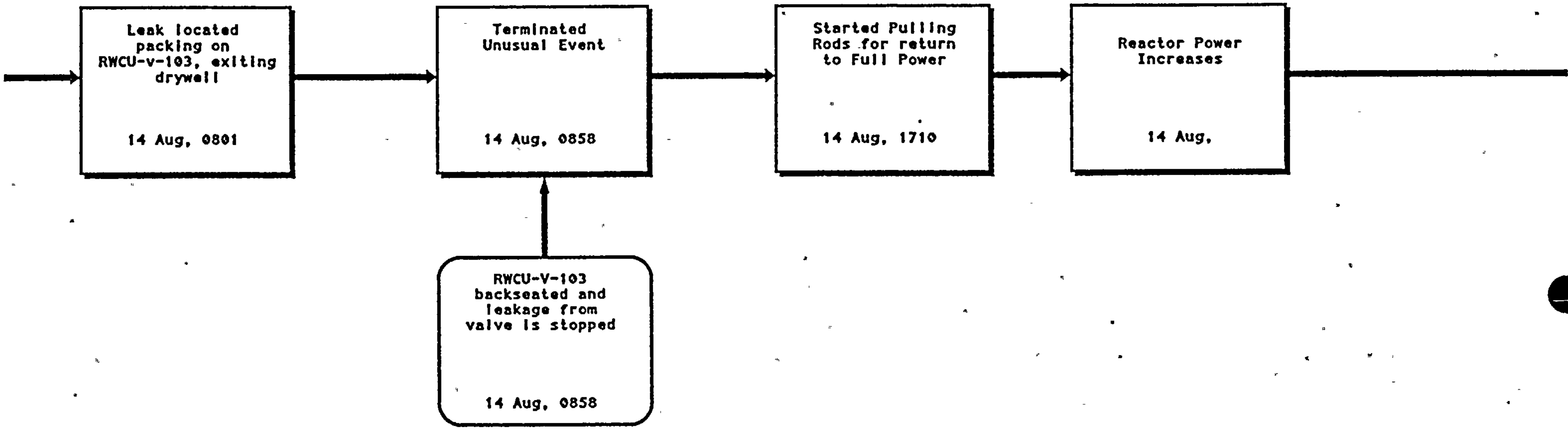

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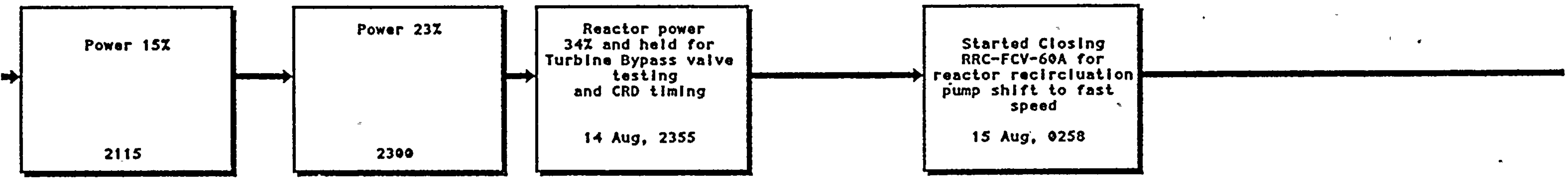

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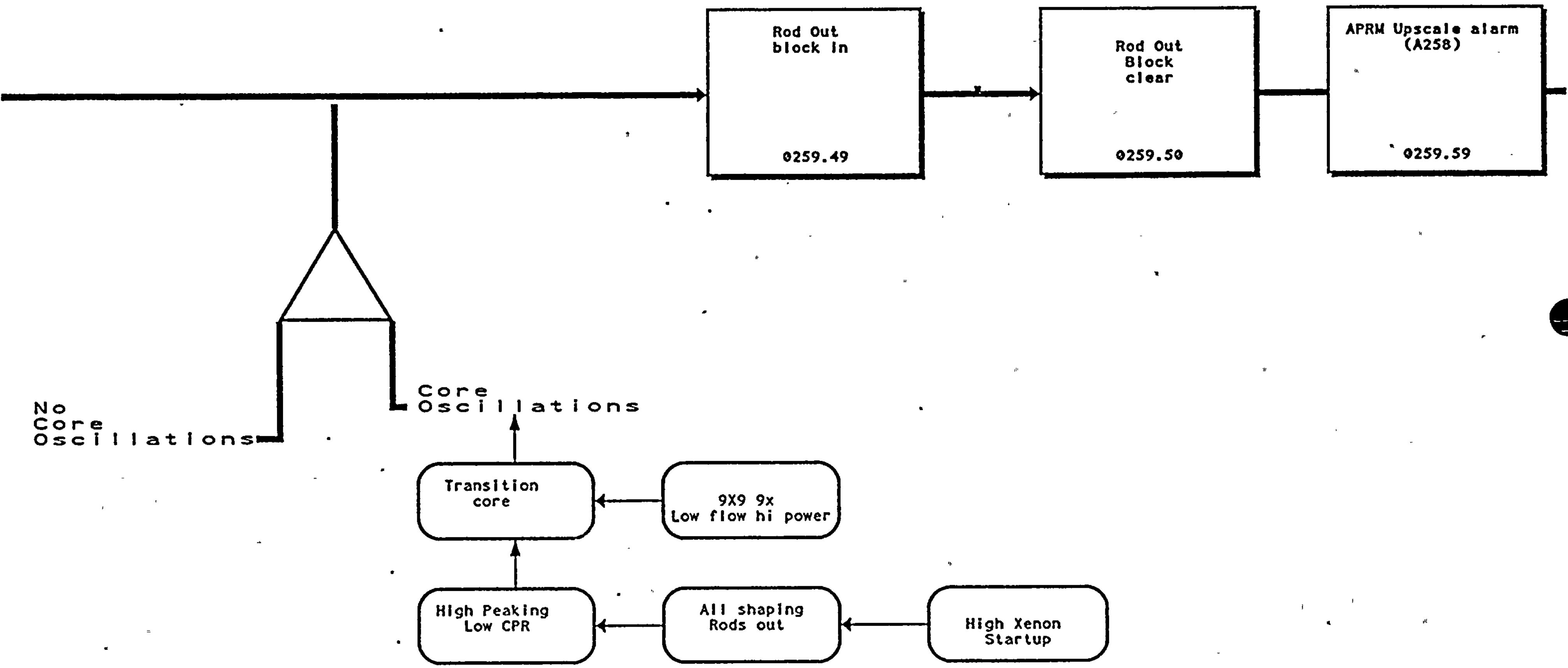

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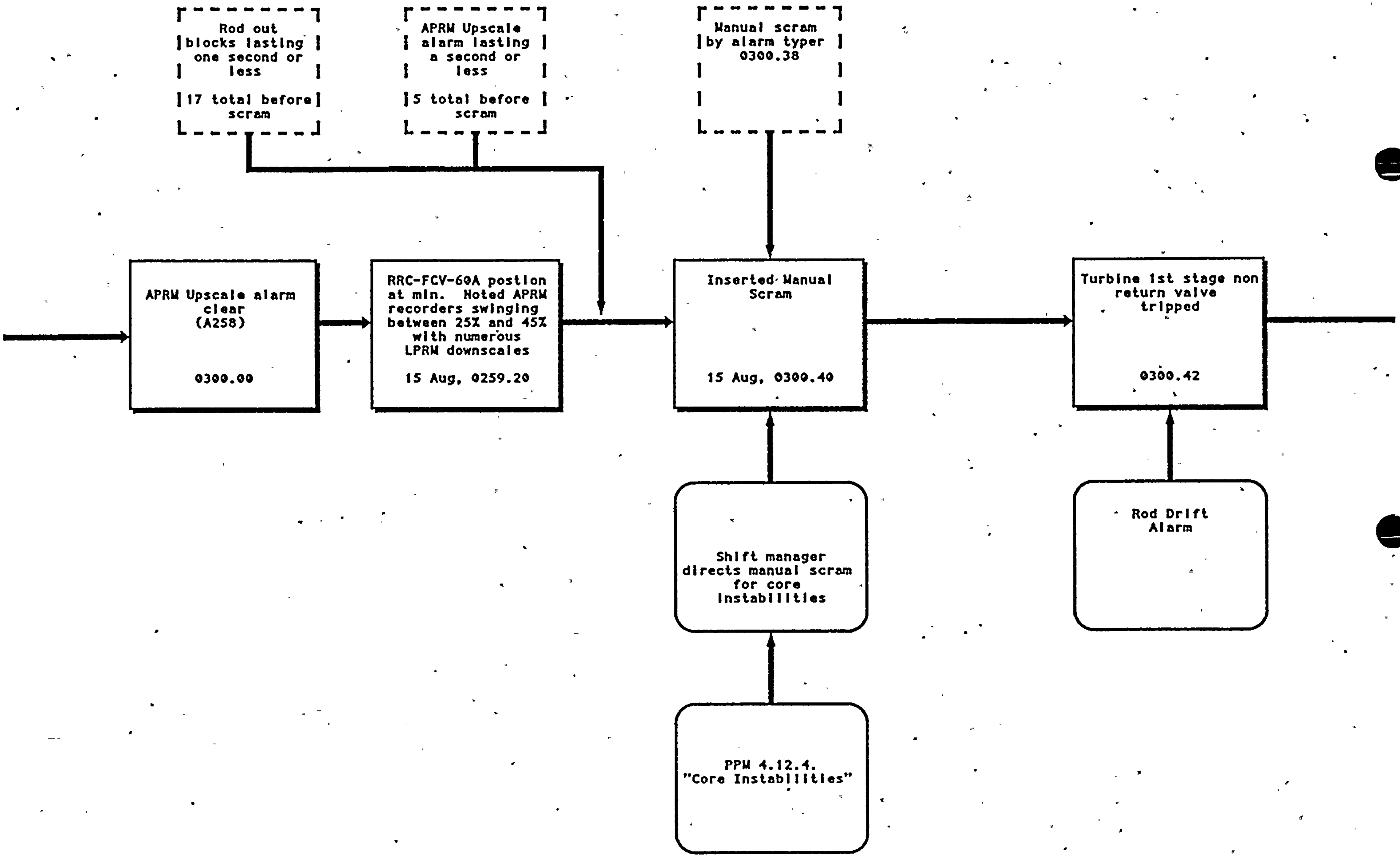
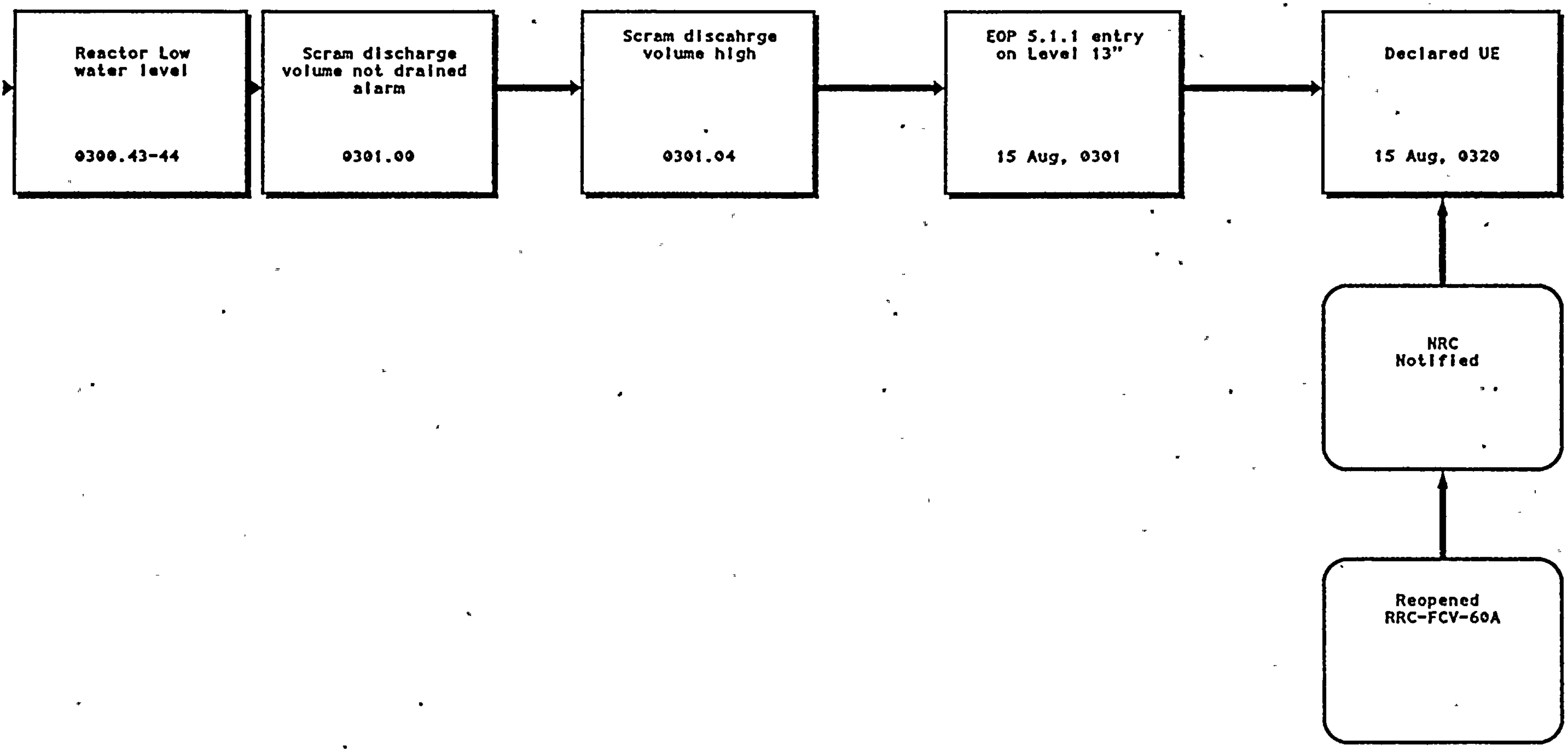
15 August 1992



Reactor Power Oscillations
15 August 1992



WASHINGTON PUBLIC POWER
SUPPLY SYSTEM

INTEROFFICE MEMORANDUM

DATE: August 15, 1992

TO: J.W. Baker, WNP-2 Plant Manager, MD927M

FROM: J.E. Rhoads, Manager Operating Event Analysis & Resolution

SUBJECT: REACTOR POWER OSCILLATION EVENT ROOT CAUSE ANALYSIS PLAN

REFERENCE: Problem Evaluation Requests PER-292-0993

Per Mr. L.T. Harrold's direction following the Reactor Scram due to power oscillations experienced just prior to Recirculating Pump transfer from slow to fast speed during power ascension on August 15,1992, the following plan is submitted to perform the Root Cause Analysis (RCA).

Procedure Compliance: This RCA will be performed under the requirements of PPM 1.3.48, "Incident Investigation". This will include utilizing all facets of investigative techniques normally used for a level one investigation with the possible exception of performing a Management and Oversight Risk Tree Analysis (MORT). A MORT analysis will be performed if necessary to definitively define the root cause.

Team Members:

C.M. Powers	Director	Senior Mgt. Coordinator
J.E. Rhoads	OEAR	Team Coordinator
J.J. Muth	OEAR	Principle Investigator
J. Ingham	Consultant	Seimens Power Co.
H. Pfefferlen	Consultant	General Electric
D. Salmon	Consultant	General Electric
P.C. Hoffmeier	Program Manager	INPO

Design analysis and Spatial Effects Investigations Committee:

D.L. Whitcomb	Nuclear Eng.	Manager
R.O. Vosburg	Safety Anal. Eng.	Supervisor
Dale Bush	Safety Anal. Eng.	Consulting Engineer
D.H. Thomsen	Fuels Eng.	Supervisor
Dr. B.M. Moore	Fuels Eng.	Consulting Engineer
D.R. Skeen	Fuels Eng.	Pr. Core Analysis Eng.
Y.Y. Yung	Safety Anal. Eng.	Senior Engineer

Plant System Effects Investigations Committee:

R.H. Torres	Plant Technical	Principle Station Nuclear Eng.
J.A. Elam	Plant Technical	Senior Station Nuclear Eng. (STA)
D.K. Atkinson	Plant Technical	Supervisor, Station Nuclear Eng.
I. Jenkins	Plant Technical	Principle Nuclear Eng.
W.J. Burke	Plant Technical	Senior NP eng.
R.A. Burk	Plant Technical	Senior NP Eng.

Operator Actions Independent Investigations Committee (QA):

J. Bass	Quality Assurance	Principle Engineer
J.A. Hammer	Quality Assurance	Principle Engineer

- In addition to the above team's action, a comparison of the WNP-2 Power oscillation event and other nuclear plant events such as LaSalle, a comparison of recent BWORG stability evaluations, and a comparison of WNP-2 Operating Strategy with other BWR5's will be performed.

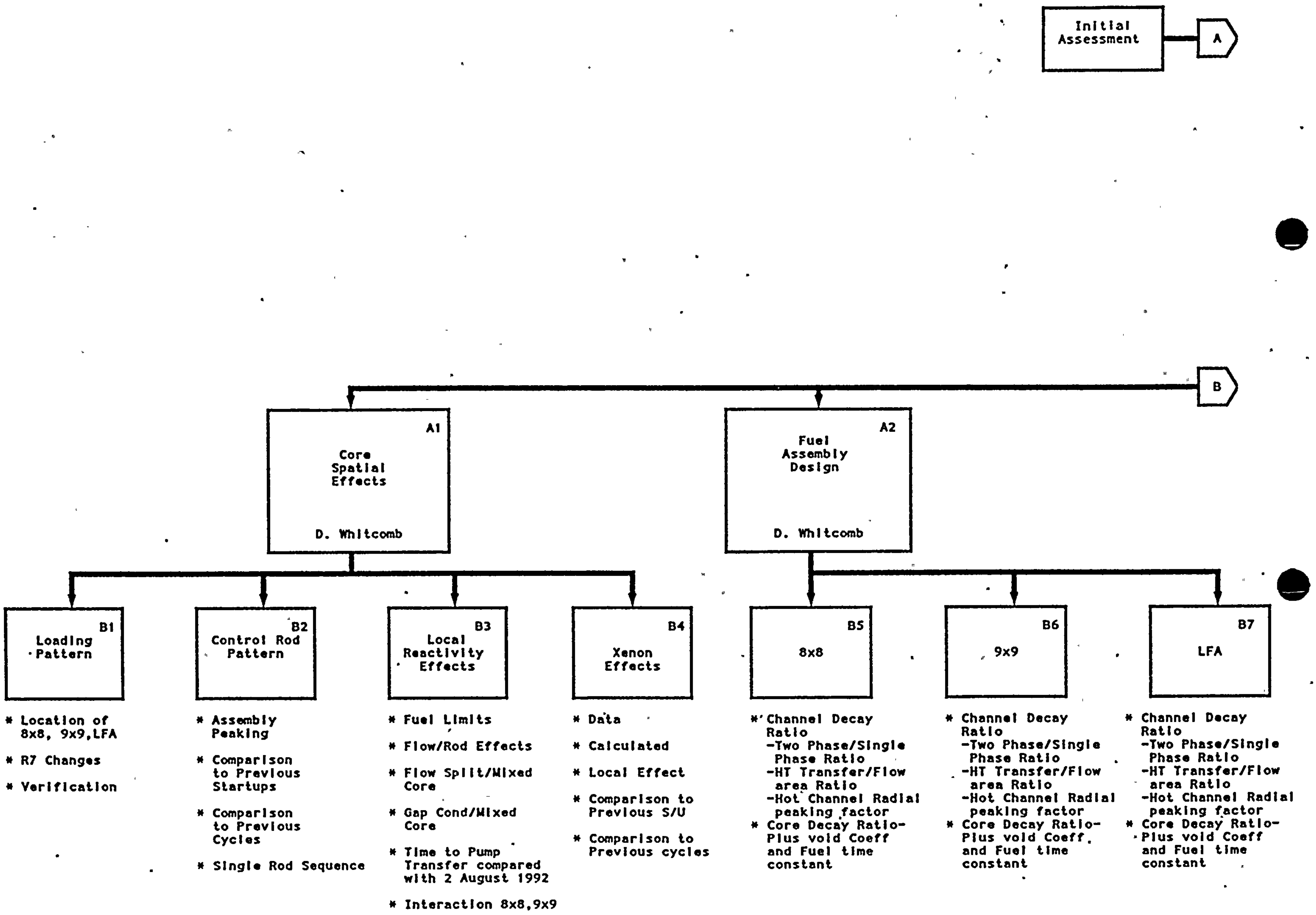
RCA Strategy:

1. Conduct an industry inquiry to determine if there has been a similar event involving Power Oscillations and if so obtain root cause and failure mechanism information.
2. Establish a detailed failure or logic tree to identify all possible conditions that could produce the observed power oscillation mode and define mechanisms that theoretically may contribute to the probability of the event occurring.
3. Construct an event and causal factor diagram to establish principle activities and changes that warrant investigation.
4. From the Industry Inquiry, Failure Tree, and Event Causal Factor Diagram establish investigative techniques to confirm or reject the potential failure mechanism or cause. Establish investigative committees to verify the conditions of the contributor at the time of the event and peruse appropriate investigative areas.
5. Assess the effectiveness of our procedures and policy to detect and suppress power oscillation of this type using the BWROG recommendations.

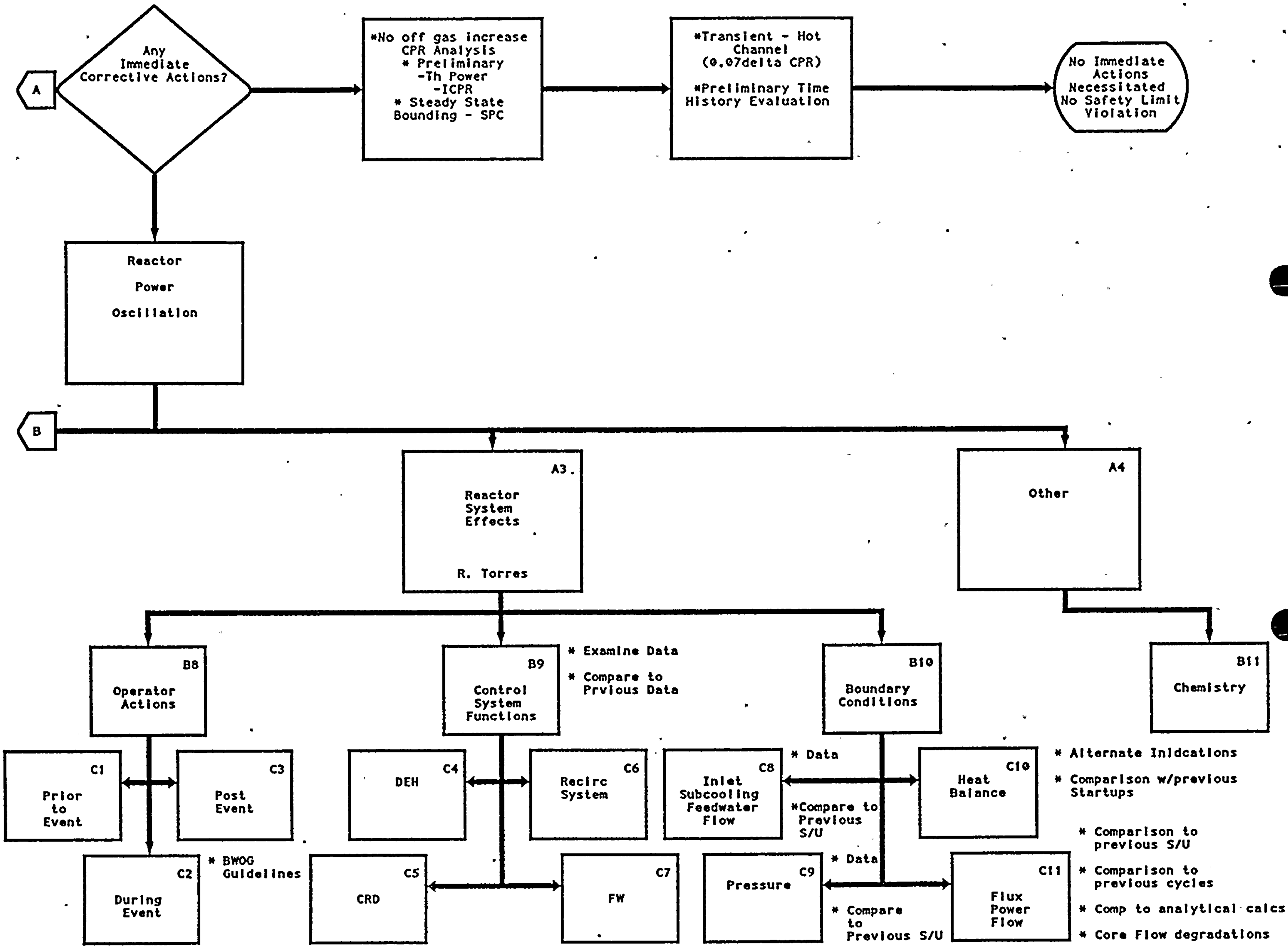
Interim reports will be provided to the Plant Management and MRC/POC as requested. The Root Cause Team recommendations on improvement of WNP-2's detect and suppress ability will be established prior to start-up of WNP-2. Confirmation or validation analysis may follow depending on the strength of the factual information discovered and its ability to explain the observed failure mode. A final report will be provided as a part of the NCR established for this event.

A "Special Management Area Issue" for this Root Cause should be established for the Plant Start-up per PPM 1.1.7 or PPM 1.3.5, as appropriate.

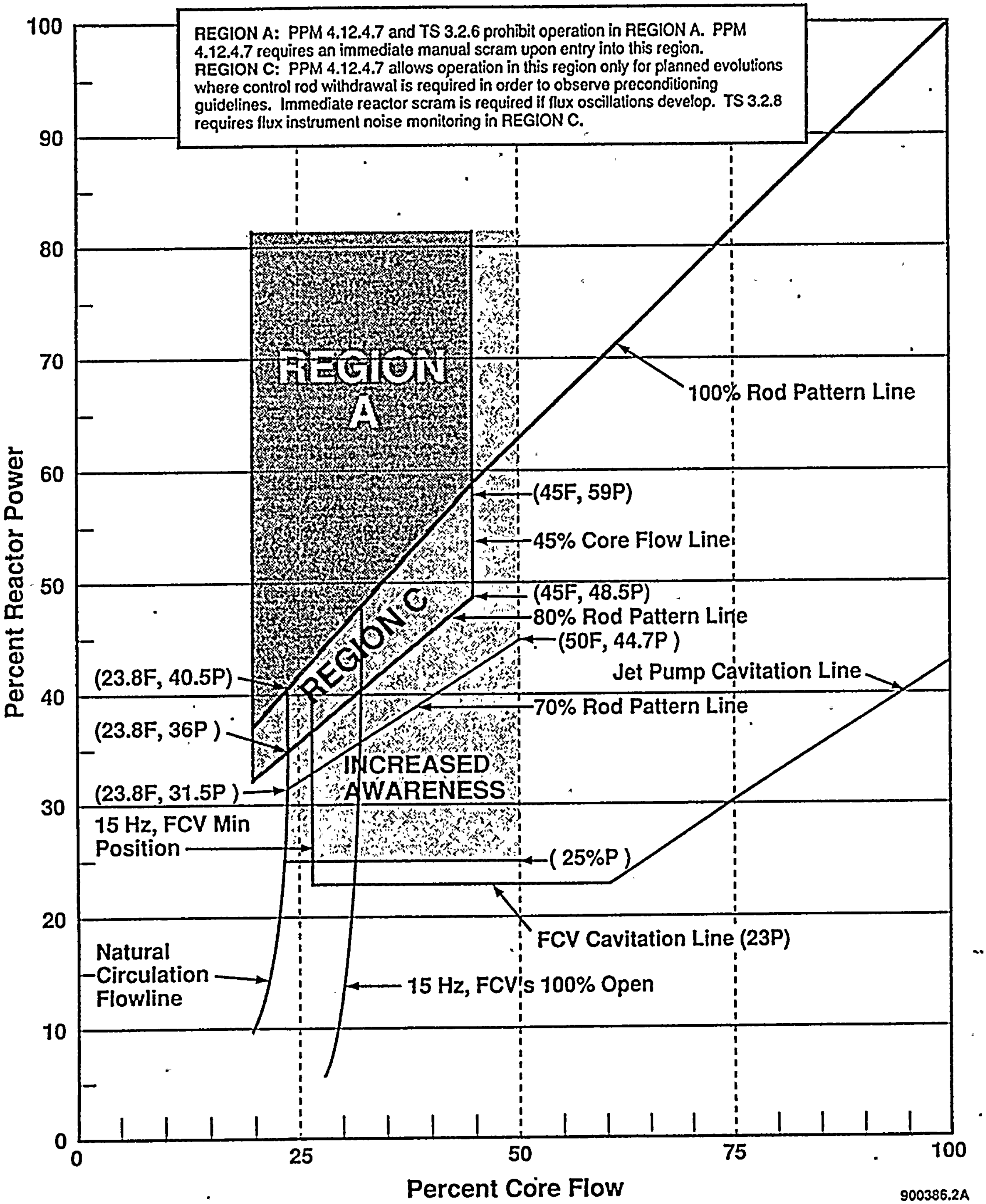
Reactor Power Oscillations 15 August 1992
Fault Tree Analysis



Reactor Power Oscillations 15 August 1992
Fault Tree Analysis



Two Loop Operation
Plant 2 Operating Map



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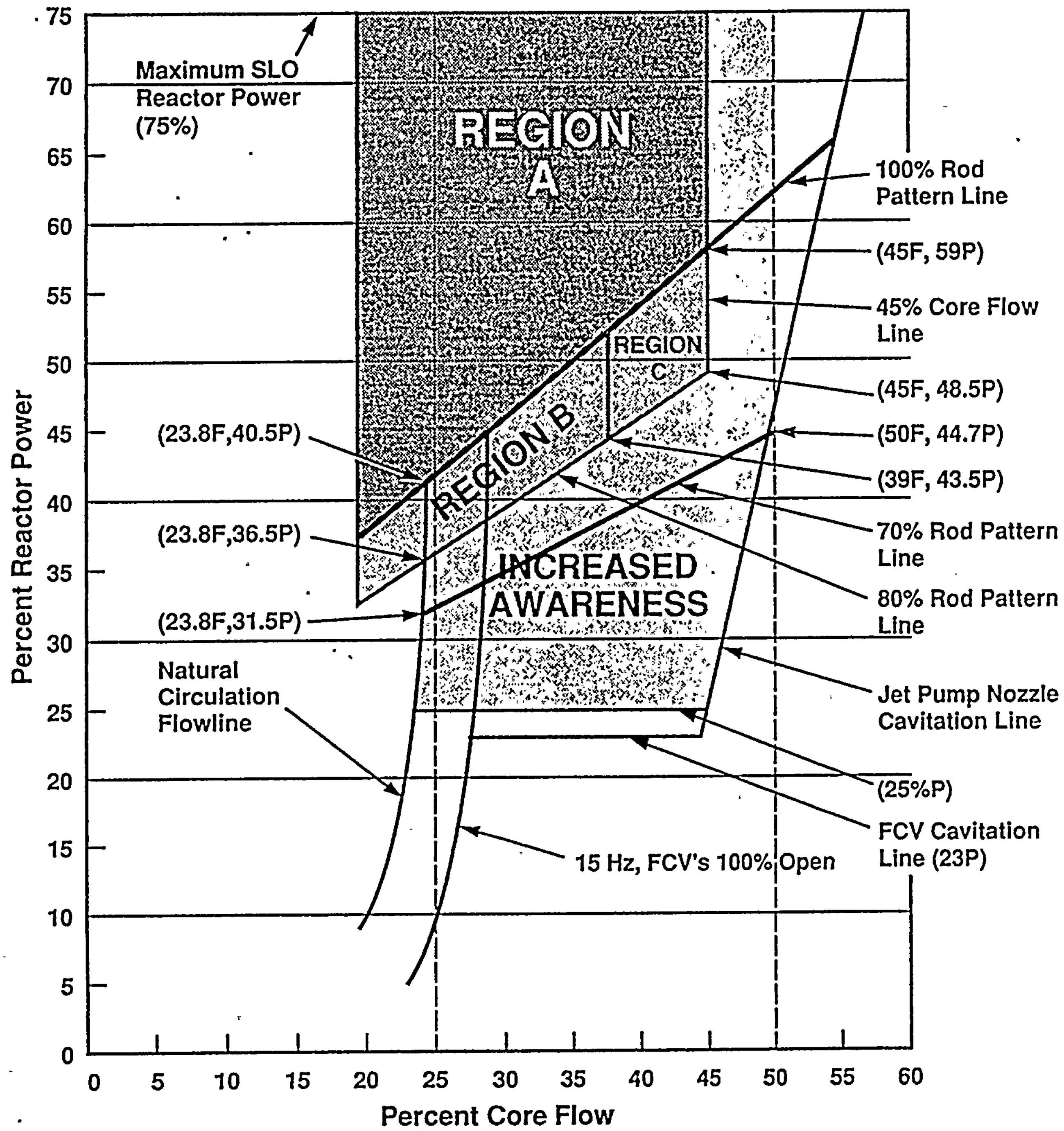
August 1992

WNP-2 Single Loop Operation Power Flow/Map



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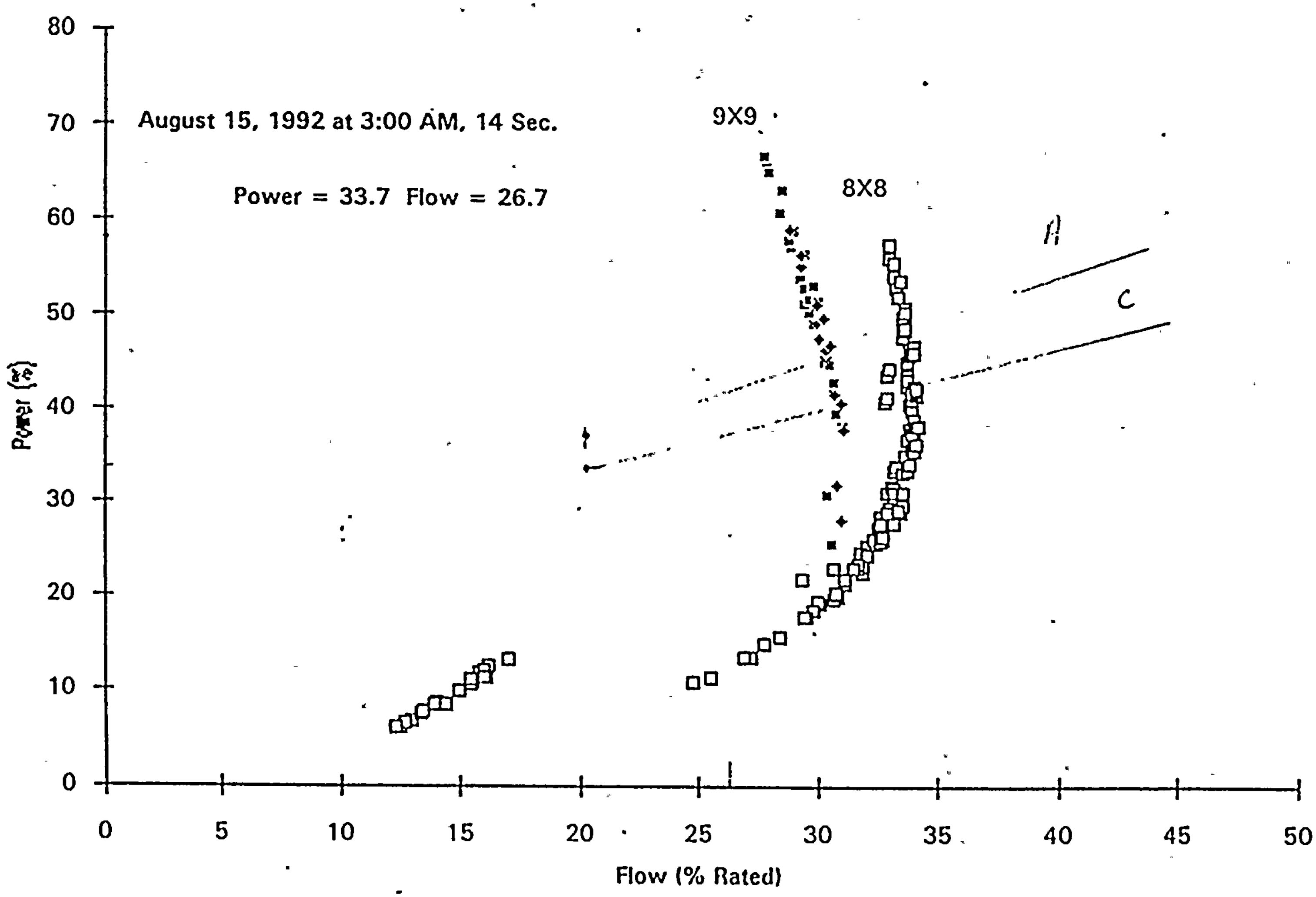
August 1992

Power Flow - Individual Assemblies



Stability Results Compared to CA Limits
(MCPR ≥ 2.1)

Supply System Supplied Values							SPC Generated Values	
Case	% Power	% Flow	Subcooling	CMPF	Avg Axial Power (loc)	MCPR	STAIF Decay Ratio	3D Decay Ratio
1	33.7	26.7	35.8	3.86	1.62 (2/12)	1.95	0.86	1.01
2	33.7	26.7	35.8				0.57	0.68
3	38.0	30.3	33.2	3.48	1.30 (3/12)	2.09	0.56	0.69
4	35.9	27.3	34.8	3.47	1.29 (3/12)	2.16	0.67	0.78
5	33.0	29.8	33.0	3.42	1.46 (4/12)	2.15	0.30	0.36
6	30.3	26.3	34.7	3.47	1.46 (4/12)	2.22	0.35	0.39
7	33.0	29.9	30.3	3.15	1.32 (4/12)	2.51	0.20	0.27
8	30.3	26.3	32.0	3.20	1.34 (4/12)	2.60	0.26	0.31
9	33.0	29.8	33.0	3.27	1.41 (5/12)	2.15	0.37	0.30
10	30.3	26.3	34.7	3.30	1.43 (5/12)	2.23	0.42	0.32
11	33.0	29.8	33.0	3.40	1.45 (4/12)	2.13	0.41	0.55
12	30.3	26.3	34.7	3.45	1.46 (4/12)	2.23	0.57	0.60
13	33.0	29.8	33.0	3.35	1.43 (4/12)	2.14	0.29	0.36
14	30.3	26.3	34.7	3.42	1.44 (4/12)	2.23	0.42	0.36

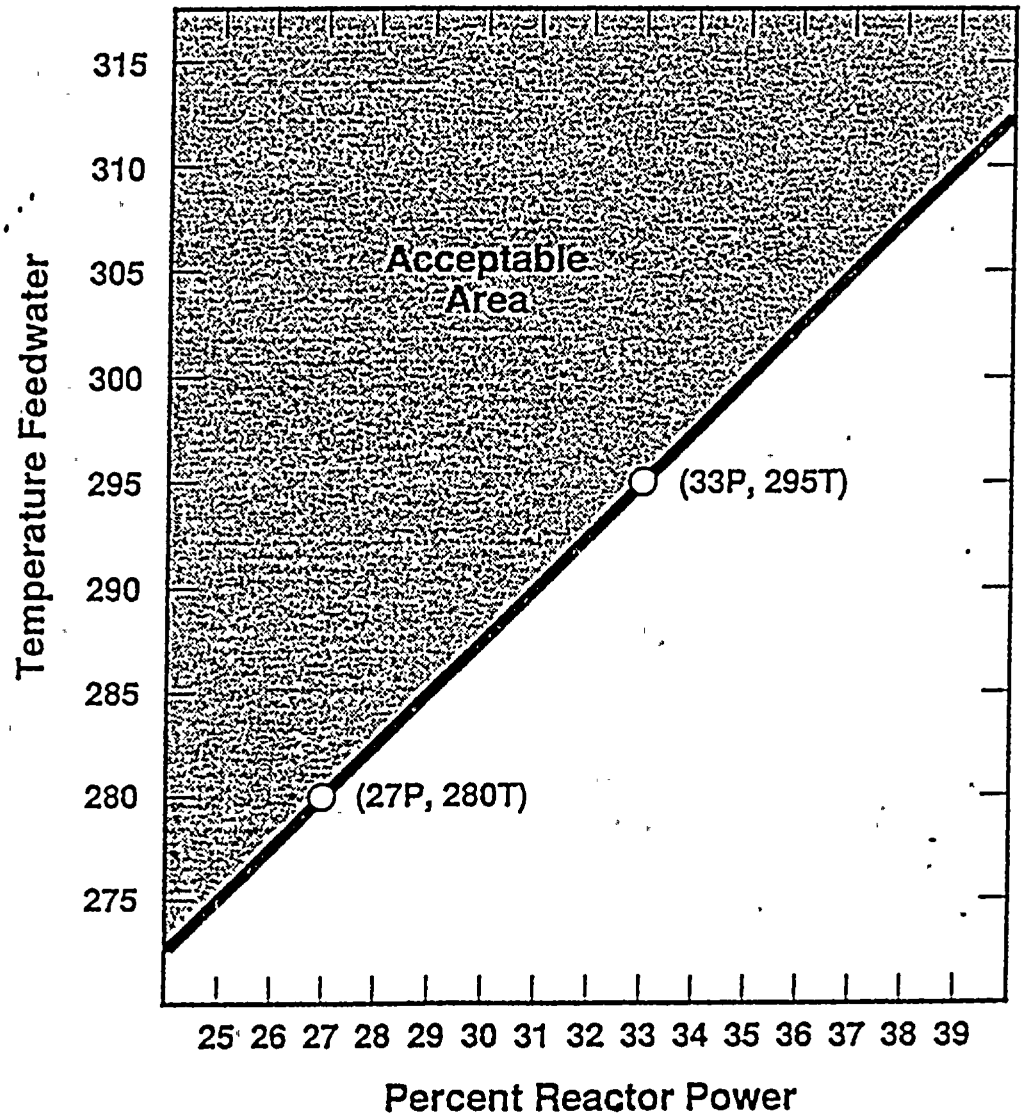
POWERPLEX CMSS Restart files provided to SNP for Stability Analysis

Case No.	Date/time stamp of the Restart file	Description of core conditions
1.	92AUG15-03:00:14	This Restart represents the actual core conditions at the time of the core instability on August 15, 1992 with one flow control valve closed. (Provided to the NRC)
2.	92AUG15	The conditions for this state point were provided to SNP by phone. This point represents core conditions at case 1 with the rod pattern for case 3, not corrected for reactivity.
3.	92AUG02-09:15:35	This Restart represents the actual core conditions before the flow control valve was closed on August 2, 1992.
4.	92AUG19-15:03:14	This Restart represents the actual core conditions with one flow control valve closed on August 2, 1992. (Provided to the NRC)
5.	92AUG22-15:09:01	This Restart represents the estimated worst case for a pump shift at the current exposure with conditions at the corrective action limits. 1. Started from the August 15, 1992. 2. Reactor shut down for 200 hours. 3. Minimum xenon, 12 hours at 25% power. 4. Power increased to 33% power and pushed to the corrective action limits.
6.	92AUG22-15:50:27	This Restart represents case 5 with conditions consistent with one flow control valve closed.
7.	92AUG23-14:27:46	This Restart represents the Best estimate of the actual startup conditions that will be present before the flow control valve is closed for initial planed startup. 1. Started from the August 15, 1992. 2. Reactor shut down for 200 hours. 3. Xenon of 20 hours at 25% power. 4. Power increased to 33% power and rod pattern adjusted to provide the maximum CPR and the lowest TPF possible.
8.	92AUG23-14:24:31	This Restart represents case 7 with conditions consistent with one flow control valve closed.

POWERPLEX CMSS Restart files provided to SNP for Stability Analysis

Case No.	Date/time stamp of the Restart file	Description of core conditions
9.	92AUG22-16:26:45	This Restart represents the estimated worst case for a pump shift at a cycle exposure 1000 MWD/MTU beyond the current cycle exposure with conditions at the corrective action limits. 1. Started from the August 15, 1992. 2. Burned at full power for 1000 MWD/MTU. 3. Reactor shut down for 200 hours. 4. Minimum xenon, 12 hours at 25% power. 5. Power increased to 33% power and rod pattern from case 5 (Corrective action limits).
10.	92AUG22-16:28:27	This Restart represents case 9 with conditions consistent with one flow control valve closed.
11.	92AUG21-23:15:28	This Restart represents conditions using the August 15, 1992 restart with a rod pattern and core conditions which meets the corrective action limits.
12.	92AUG21-23:52:06	This Restart represents case 11 with conditions consistent with one flow control valve closed.
13.	92AUG25-12:24:43	This Restart represents the estimated worst case for a pump shift at a cycle exposure 500 MWD/MTU beyond the current cycle exposure with conditions at the corrective action limits. 1. Started from the August 15, 1992. 2. Burned at full power for 500 MWD/MTU. 3. Reactor shut down for 200 hours. 4. Minimum xenon, 12 hours at 25% power. 5. Power increased to 33% power and rod pattern from case 5 (Corrective action limits).
14.	92AUG25-12:26:24	This Restart represents case 13 with conditions consistent with one flow control valve closed.

Minimum Feedwater Temperature Verses Power Prior to Recirc Pump Shift



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August 1992