ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

August 24, 1976

ACRS Members

HIGHLIGHTS OF THE PEAKING FACTORS WORKING GROUP MEETING - AUGUST 20, 1976

Attached are the highlights of the August 20, 1976, Peaking Factors Working Group Meeting on B&W core power distribution. The full minutes will follow shortly.

Paul Boehnert

Paul Boehnert
Technical Intern

Enclosure As Stated

cc: ACRS Staff
Dr. J. Lee
Dr. W. Lipinski

HIGHLIGHTS OF THE PEAKING FACTORS
WORKING GROUP MEETING
AUGUST 20, 1976
WASHINGTON, D. C.

On August 20, 1976, the Peaking Factors Working Group met in Washington, D.C., to discuss power distribution in reactor cores fabricated by Babcock and Wilcox (B&W). Working Group members in attendance included Drs. Kerr and Mark. Consultants present included Drs. Lee and Lipinski. Significant pointed discussed at the meeting included the following:

1. B&W has two classes of plants: (1) "rodded" plants, and (2) "feed and bleed" plants. In the rodded plants, slow reactivity transients are controlled via control rod assemblies (CRA). The feed and bleed plants control slow reactivity transients by varying the soluble boron concentration in the reactor coolant. Both classes of plants use part length control assemblies.

2. B&W uses both in-core and ex-core detectors. The in-core detectors are not intercalibrated. The Working Group questioned how a malfunctioning in-core detector would be detected and accounted for in measurement analysis. The ex-core power detection system relies on 4 split uncompensated ion chambers, 12 feet in length. The ex-core output signals from the top and bottom detector string are summed. The summed output signal is preportional to the total reactor power.

3. A load transient (75%-35%-75%), for a rodded plant was reviewed. For B&W plants, the average core temperature is held constant. Control is maintained by maneuvering the control rods to balance the xenon and doppler reactivity feedback effects occurring through the transient.

4. Describing the allowable core inbalance as determined by ex-core instrumentation, it was noted that B&W employs two parameters for controlling the peaking factor: (1) control rod position limits, and (2) magnitude of core axial power inbalance. At full power, the axial inbalance maneuvering band is restricted to 6 to 7% before alarm limits are reached. This is due to the transient xenon penalty required to stay within LOCA KW/ft limits.

5. There was considerable discussion on the topic of quadrant tilt, i.e. its measurement and determination. The Staff noted that while B&W is required to monitor for quadrant power tilt the method of tilt monitoring is not specified. After further discussion it was

noted that because the ex-core detector readings are normalized frequently, the in-core detectors must be relied on as the basis for power tilt measurement.

6. B&W utilizes a "hold" on return to power during a transient to mitigate the consequences of transient xenon (by burnout) on the peaking factor. The power hold reduces the xenon effect on F_Q by approximately 7% for rodded plants and 8% for feed and bleed plants.

7. The power distribution calculations performed were reviewed. B&W performs three sets of design calculations. These are: (1) full power equilibrium xenon calculations, (2) design transient calculations (100%-50%-100% for feed and bleed plants, 100%-30%-100% for rodded plants), and (3) calculations for off normal conditions i.e. mismanagement of axial power shaping rods, etc.

8. The uncertainty factors accounted for in the calculation used to determine the rod insertion limits and axial inbalance limits were discussed. Measurement uncertainties were also reviewed. Because the topicals dealing with the overall subject of uncertainty analysis have yet to be published, the discussion was general in nature.

CERTIFIED
12/16/76

MEETING DATE: 8/20/76
DATE ISSUED: 12/1/76

MINUTES OF THE ACRS PEAKING FACTORS
WORKING GROUP
AUGUST 20, 1976
WASHINGTON, D. C.

On August 20, 1976, the Advisory Committee on Reactor Safeguards Peaking Factors Working Group, met in Washington, D.C., to discuss the measuring of power distribution in light water reactors, whose core are fabricated by Babcock and Wilcox (B&W). The notice of the meeting appeared in the Federal Register, Volume 41, Number 152 - Thursday, August 5, 1976. There were no requests received for oral or written statements by members of the public, and none were made at the meeting. Attachment A is the meeting agenda. The attendees' list is Attachment B. A tentative schedule is Attachment C to the minutes. Slides and handouts used at the meeting are Attachment D to these minutes.

EXECUTIVE SESSION 8:35-9:45 a.m. (CLOSED)

Dr. Kerr, Working Group Chairman, askied if any members of the Working Group had questions regarding B&W power distribution measurement. A Working Group member asked if B&W plants had core power distributions in transient load follow maneuvers similiar to Westinghouse (W) plants, and if so, how was axial offset control maintained? Dr. Kerr felt B&W peaking factors were not as low as W's, and suggested that comparative problems between B&W and W plants be highlighted.

The Working Group also noted that many of the B&W Topicals shown on the list provided by the NRC Staff (Attachment D-26-28) dealing with core physics calaculations and uncertainty measurements are yet to be published.

The status of the NRC report on power distribution for light water reactors was also discussed.

OPEN SESSION 9:10 a.m. - 4:02 p.m. INTRODUCTION

Dr. Kerr, Working Group Chairman, called the meeting to order at 9:10 a.m. The Chairman stated the purpose of the meeting and explained the procedures for conducting the meeting, pointing out that Mr. Thomas G. McCreless was the Designated Federal Employee in attendance.

Mr. Dan Fino, NRC Staff, introduced Mr. Walt Brooks to begin the discussion by describing B&W reactors, and the in-core and ex-core instrumentation used.

B&W REACTOR AND NEUTRON DETECTION INSTRUMENTATION DESCRIPTION

Mr. Brooks described the B&W core components, including the fuel assemblies, control rod assemblies (CRA), and in-core and ex-core instrumentation available. B&W has reactors of three sizes: 145, 177, and 205 fuel assembly cores. The meeting discussions centered on the 177 assembly core presently being offered by B&W. Current reactors use the 15x15 fuel assembly (Fig. 2); control assemblies contain 16 control rod guide tubes (CRGT). These tubes may contain water, lumped burnable poison (B_4C), or control rods, depending on need. The new 17x17 fuel assemblies will contain 24 CRGT's. In-core instrumentation tubes are located in the center of selected assemblies.

A slide of control rod assemblies arranged by groups was shown (Fig. 4), for a 205 assembly plant. Groups 1-4 are safety rods; groups 5-7 are regulating rods, and group 8 rods are part length (3 feet) axial power shaping rods (APSRA). B&W operates two types of reactors, "rodded" and "feed and bleed," plants.

Describing the regulating rod group withdrawal mode, Mr. Brooks said the three rod groups are independently operated in the rodded plants. Rod groups 6 and 7 operate in unison in the feed and bleed plants. There is a 25% overlap in the withdrawal positions for the rods, i.e. when group 5 passes the 75% withdrawal mark, group 6 starts to withdraw, etc. (Fig. 5).

Mr. Brooks described the in-core detectors used. For the 177 assembly plant, there are 52 in-core detector strings with 7 rhodium detectors per string, (Fig. 7). Based on 1/4 core symmetry there is a "detector" for each fuel assembly; symmetry monitors determine quarter core symmetry. A background detector is also utilized, and a calbiration tube is provided for a movable in-core calibration unit. At present, none of the utilities have used moveable in-core calibration detectors.

A discussion ensued concerning the fact that the in-core detectors are not intercalibrated. B&W maintained that a malfunctioning detector can be easily spotted and accounted for by analysis. The in-core detectors are replaced every 3 to 4 fuel cycles. Dr. Lee did not feel that fuel enrichment anomalies affecting as much as an entire asembly could be detected without in-core detector intercalibration. Dr. Lipinski asked about the accuracy of the in-core detectors at end of life. Mr. Bozarth (B&W) said he would send a B&W topical that contains that information to the Working Group in the near future.

Mr. Brooks described the ex-core detector system used by B&W. The power detection system uses four split uncompensated ion chambers, (Fig. 9). The detectors are not uniformly positioned around the reactor vessel (Fig. 10), due to space limitations.

The electronic signal system for each detector was reviewed (Fig. 11). Mr. Brooks noted that the signals for power and Δ flux indications pass through three amplifiers with three separate gain settings.

Dr. Kerr referred back to an earlier question on the detection of fuel amomalies via the in-core instruments, and asked the Staff if there was information available on the probability of a fuel assembly containing an enrichment anomaly finding its way into a reactor core. The Staff said work was initiated in this area one year ago, but no report has been produced.

"RODDED" VS. "FEED AND BLEED" PLANTS - M. DUNENFELD

Mr. Dunenfeld reviewed the differences between the "rodded" and "feed and bleed" classes of B&W plants in terms of reactivity control (Fig. 12). The major difference is the method of transient xenon control. Replying to Dr. Kerr's question, Mr. Dunenfeld said B&W reactors operate at a constant average core temperature. Mr. Richings said he would address this point shortly in his presentation. The feed and bleed plants rely primarily on boron concentration manipulation with some rod movement for control of transient xenon. The Staff noted that rodded plants have less operating flexibility because of the lower LOCA imposed peaking factors.

Mr. Richings reviewed data from a 15.5 hour start-up test transient (75%-35%-75%) for a B&W rodded plant, (Fig. 13). Parameters detailed included: (1) rod positions for groups 6, 7, and part length rods, (2) core imbalance; (3) power level; (4) reactivity feedback; (5) radial peaking factors, and (6) an overall core peaking factor. The two principle reactivity feedback effects are the doppler and xenon feedback. The rod groups are maneuvered to balance these feedbacks. As xenon is burned out (about 10 hours into the transient) rods must be inserted to maintain criticality.

The maximum core peaking factors, and five largest radial peaking factors seen in the fuel assemblies during the test transient were discussed. Mr. Richings pointed out that the location of the peak power shifts from the center of the core towards the core bottom during the transient. This power shift introduces a conservatism in the decay heat LOCA analysis of 5-10%. The LOCA analysis assumes power distribution characteristics of worst peak and location, ignoring the actual shift of power (and decay heat) as shown by the start-up test data. For a feed and bleed plant, most of the transient xenon feedback described above would be compensated for by boron concentration manipulation. Replying to a question from Dr. Lee, Mr. Gudorf (B&W) said the feed and bleed plants do see a reduction in transient response capability because of low boron concentration near end of cycle. The Staff said that if the transient response problem is significant, operating restrictions are imposed on the plant.

Mr. Dunenfeld reviewed the rod position limits for a feed and bleed plant, (Fig. 14). B&W employs two parameters for control of the core peaking factor: (1) control rod position limits, and (2) magnitude of core axial power imbalance. It was noted that (1) the control rod operating band is rather narrow at full power, and (2) control rods cannot be fully withdrawn at full power. The rod position limit curve is more complex for a rodded plant. Dr. Kerr asked why the dotted line identified as "operating limit for continuty" appears on the graph. B&W said additional computer software would be required to program in alarm limits for the broken line, and this additional operability did not justify the added software expense.

A sample graph of the operational core power "envelope" was shown, (Fig. 15). Responding to Dr. Mark's question, Mr. Dunenfeld said the discontinuity in envelope shape for the positive and negative imbalance values results from the ECCS-LOCA limit curves.

Technical specifications require an in-core flux map once a month. Mr. Dunenfeld said that the in-core detectors are used to calibrate the ex-core detectors, and spot any possible power distribution problems. There is no requirement for the use of in-core detectors on a day-to-day basis to monitor power distribution. B&W is required to monitor for quadrant power tilt. Replying to Dr. Kerr's questions, Mr. Dunenfeld said the method of monitoring power tilt is left to B&W.

A graph of ex-core radial tilt vs change in peak power was described (Fig. 16). Dr. Kerr inquired as to how the value for the abscissa ("tilt in least sensitive position") is obtained from the ex-core detector outputs. Briefly, the procedure described by B&W was as follows: (1) the four readings from the detectors are summed and an average is determined; (2) for each detector a % deviation from the average is determined; (3) the angle between the tilt direction and the out of core detector must be known. B&W assumes a "least sensitive" angle of 57.5^{o} between the tilt direction and the detector location, i.e. at this angle, the detector "sees" the smallest percent of the actual tilt occurring; (4) the change in the power peak as a function of the tilt is determined; (5) the largest positive value determined at step (2) is plotted on the abscissa, and the value for step (4) is plotted on the ordinate.

Mr. Dunenfeld said the line on the tilt vs peak power graph (Fig. 16) envelopes the largest expected change in peak power as a function of ex-core tilt. Mr. Dunenfeld attempted to correlate the slope value (1.84) shown on the above graph to results obtained by W in similiar type experiments. Dr. Kerr said that a one-to-one comparison between the two vendors should probably not be made since it is quite likely each vendor has a different definition of "tilt". The Staff is currently studying this problem of comparing peaking factor change via power tilt measurement.

Mr. Dunenfeld also went on to say that for quadant tilt monitoring via the ex-core detectors, B&W uses the signal that is also used to measure core power. (Fig. 11). This signal is a summation of the signals from the top and bottom detectors. There is concern on the Staff's part that for certain tilts, i.e.

tilt caused by partially misaligned congrol rods, there may be a loss of detector sensitivity. Responding to a question, Mr. Bunenfeld said that, at present, no requirements have been imposed to use the in-core detectors if a tilt appears. In practice however, when an anomaly is seen, operators will take appropriate corrective action.

There was considerable discussion concerning the calibration of the ex-core detectors. The technical specification calibration requirements for the ex-core detectors, specify that twice weekly the "total power" reading of the detectors be compared to the calorimetric heat balance total power computation. Instrument channel calibrations are required if a 2% or greater deviation is seen between the two results. The ratio of the top to bottom ex-core detector readings is calibrated to the in-core imbalance readings.

Dr. Kerr questioned the practice of recalibrating the ex-core detectors daily or twice weekly, pointing out that a slow tilt would be "normalized out" with frequent recalibration. After further discussion, it was determined that, in fact B&W must rely on the in-core detectors as the basis for quadrant tilt measurement. Mr. Gudorf said B&W takes a 7.5% penalty on their peaking factor to account for possible quadrant tilt. The in-core detector indication of tilt is an alarm function.

Mr. Dunenfeld described an operating restriction imposed on B&W plants to deal with transient xenon effects. For severe load following transients, the peaking factor (F_Q) can be pushed to 16% above the calculated value. A power "hold" is made at 90% of full power to mitigate the effects of the transient xenon on F_Q. F_Q is reduced by 7% for rodded plants, and 8% for feed and bleed plants as a result of this power "hold". This restriction applies to the first cycle of all 177 assembly plants and subsequent fuel cycles of the rodded plants. The Staff is working to determine whether feed and bleed plants beyond first cycle must utilize a power hold. The method of transient xenon analysis used to determine the power hold requirement was discussed. In reply to Dr. Kerr, Mr. Gudorf said BAW-10078 "Operational Parameters for B&W Rodded Plants," (Proprietary), contains information on xenon transient analysis.

The various alarmed plant operating parameters were reviewed, (Fig. 17). In reply to Dr. Lee, Mr. Coppola (B&W) said the in-core detector quadrant tilt alarm setpoint is 4.10%; the ex-core detector alarm setpoint is 2.86%. In response to another question, Mr. Coppola said there have been restrictions imposed on reactor maneuverability because of the tight power envelope in the 90 to 100% power range. If setpoint limits are exceeded, the technical specifications allow the operator two hours to get the imbalance back within limits. Power reduction is required if corrective action is unsuccessful.

POWER DISTRIBUTION ANALYSIS CALCULATIONS - LOCA LIMITS DETERMINATION
W. BROOKS

Mr. Brooks began by reviewing the three sets of design calculations performed for power distribution analysis, (Fig. 18). These are: (1) full power equilibrium xenon effects for various milestones in the plant fuel cycle; (2) design transient conditions (100%-50%-100% for feed and bleed plants, and 100%-30%-100% for rodded plants). These transients are limiting because of LOCA considerations; (3) off normal condition such as mismanagement of the part length axial power shaping rods, etc. There are no operating restrictions on the part length rods in B&W reactors.

The calculation performed to determine the heat flux as a function of elevation was discussed, (Fig. 19) The various uncertainties accounted for by B&W were reviewed. Uncertainty factors noted included (1) axial - local factor to account for the effect of spacers in the fuel assemblies; (2) power spike factor which accounts for densification; (3) hot channel factor; (4) nuclear uncertainty factor; (5) *nonequilibrium xenon penalty factor*;

(6) quadrant tilt penalty factor; (7) rod bowing penalty factor, and (8) part length rod mismanagement factor. Dr. Lipinski asked how B&W verifies a 2% accuracy on their calorimetric heat balance calculation. B&W said a recent uncertainty reevaluation shows their best estimate calculations contain a 1.25% uncertainty, thus 2% is a conservative value.

The radial-local peaking factor used in the heat balance calculation described above is defined as the ratio of the hot pin power to the average bundle power. A two dimensional-quarter core PDQ calculation is used to determine this quantity. A radial-local peaking factor is determined for each core assembly and is a function of burnup, fuel type, core composition, and whether or not the fuel bundle contains CRA's.

Transient xenon concentration seen during a design power maneuver was shown (Fig. 21). Dr. Lee asked if the 7% reduction in F_Q described earlier (Page 7) had been verified by measurement. B&W replied that no plant experiments have been run to verify this partial xenon penalty value. The value of the full transient xenon penalty (16%) has been experimentally verified, and B&W topical BAW-10125 "Verification of Three-Dimensional FLAME Code" contains analytical analysis of the full transient xenon penalty.

The LOCA limits for the maximum allowable heat rate (KW/ft) as a function of core height was reviewed, (Fig. 22). At mid core, the maximum limit is 18.0 KW/ft.

Mr. Brooks discussed the procedures for establishment of technical specification operating limits, i.e. rod position limits, and core axial imbalance limits. Rod insertion limits are determined as follows: (1) for each core level, a plot of the maximum heat generation rate (H_Z), as a function of rod position is made; (2) the curve from (1) is compared to LOCA allowable heat generation rates for each core level to determine the rod position range permitted; (3) the most restrictive rod position range from all core levels considered is noted. This most restrictive rod position range would be the rod position operating limits used. The axial imbalance limits are determined by: (1) reviewing the rod position limit calculations above; (2) calculating the axial imbalance for each core level from these calculations, and (3) selecting the most restrictive axial imbalance value from the calculations for the operating limit.

The procedures for calibration of the ex-core detectors was discussed. Measurements of axial imbalance are made with the in-core detectors during startup physics tests. The ex-core "difference" amplifier gajn is adjusted to read the same value for imbalance as seen by the in-core detectors. A plot of in-core vs ex-core offset was shown (Fig. 25). Mr. Coppola said that the instrument "drift" seen for axial imbalance measurements is only about 2%/year of operation.

There was a discussion of the uncertainty in measurement. The discussion was not as detailed as discussion with other vendors on this topic has been in the past, and Dr. Kerr asked for an appropriate topical report dealing with this subject matter. Mr. Brunsen (B&W) said topical report BAW-10121 "Reactor Protection System Limits and Setpoints," will be published in January, 1977 and will adddress instrument uncertainties.

Mr. Brooks described the technical specification operational limits (Fig. 15), including the in-core and ex-core detector setpoint limits. Limits for a "degraded" in-core system (operation with less than full complement of functioning in-core detectors), are inside the ex-core setpoints. In reply to Dr. Lee, Mr. Brooks said there is a 6-7% maneuvering band at full power before alarm limits are reached. Replying to Dr. Kerr's questions Mr. Coppola said if alarm limits are exceeded, the operator has a choice of actions to bring the imbalance within limits. Normally the APSR's are adjusted in lieu of power reduction.

Dr. Lee asked why there is such a restrictive operating band from 80% to 90% power and 90% to 100% power, (Fig. 15). Mr. Gudorf said that because of the transient xenon peaking penalty taken at 90% power and above, and the requirement to maintain LOCA KW/ft. limits, the axial offset has had to be restricted. Below the 90% power level, a larger power peak is allowed, which in turn allows the use of a bigger axial offset.

Dr. Kerr closed the meeting by thanking all participants involved and noted that the Working Group may request additional information from B&W at a later date.

The meeting was adjourned at 4:02 p.m.

NOTE: A complete transcript of this meeting is on file at the NRC Public Document Room at 1717 H Street, N.W., Washington, D.C., or can be obtained from ACE Federal Reporters, Inc., 415 Second Street, N.E., Washington, D.C. 20002 (202) 547-6222.

DOCUMENTS MADE AVAILABLE TO THE WORKING GROUP FOR THE AUGUST 20, 1976 MEETING

1. Visual aids used in presnetations (attached to minutes)
   a. Vu-graphs used by the NRC (25)

2. Additional information made available
   a. List of B&W Topicals on Power Calculations and Core Power Distribution from the NRC Staff

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS WORKING GROUP ON PEAKING FACTORS

Meeting

In accordance with the purposes of Sections 29 and 182b. of the Atomic Energy Act (42 U.S.C. 2039, 2232(b)), the ACRS Working Group on Peaking Factors will hold a meeting on August 20, 1976 in Room 1046, 1717 H St., N.W., Washington, DC 20555. This is the fifth of a series of meetings to review current methods of measuring power distribution in light-water power reactors whose cores are fabricated by the various reactor vendors. This meeting will be used to discuss power distribution in reactors whose cores have been fabricated by the Babcock and Wilcox Company.

The agenda for the subject meeting shall be as follows:

Friday, August 20, 1976, 8:30 a.m. Members of the Working Group will meet in closed Executive Session, with any of their consultants who may be present, to explore their preliminary opinions regarding matters which should be considered during the open session so that the Working Group can prepare a report and recommendations to the full Committee.

9:00 a.m. until conclusion of business. The Working Group will meet in open session to discuss with representatives of the NRC Staff and the Babcock and Wilcox Company current methods of measuring power distribution in nuclear reactor cores built by the Babcock and Wilcox Company.

At the conclusion of the open ssesion, the Working Group may caucus in a brief, closed session to determine whether the matters identified in the initial closed session have been adequately covered. During this session, Working Group members and consultants will discuss their opinions and recommendations on these matters.

In addition to these closed deliberative sessions, it may be necessary for the Working Group to hold one or more closed sessions for the purpose of exploring with the NRC Staff and representatives from other Government agencies and the nuclear industry matters involving proprietary information, particularly with regard to specific features of plant designs.

I have determined, in accordance with Subsection 10(d) of Public Law 92-463, that it is necessary to conduct the above closed sessions to protect the free interchange of internal views in the final stages of the Working Group's deliberative process (5 U.S.C. 552(b)(5)) and to protect proprietary information (5 U.S.C. 552(b)(4)). Separation of factual material from individuals' advice, opinions and recommendations while closed Executive Sessions are in progress is considered impractical.

Practical considerations may dictate alterations in the above agenda or schedule. The Chairman of the Working Group is empowered to conduct the meeting in a manner that, in his judgment, will facilitate the orderly conduct of business, including provisions to carry over an incompleted open session from one day to the next.

With respect to public participation in the open portion of the meeting, the following requirements shall apply:

(a) Persons wishing to submit written statements regarding the agenda items may do so by providing a readily reproducible copy to the Working Group at the beginning of the meeting. Comments should be limited to safety related areas within the Working Group's purview.

Persons desiring to mail written comments may do so by sending a readily reproducible copy thereof in time for consideration at this meeting. Comments postmarked no later than August 13, 1976 to Mr. T. G. McCreless, ACRS, NRC, Washington, DC 20555 will normally be received in time to be considered at this meeting.

(b) Those persons wishing to make an oral statement at the meeting should make a written request to do so, identifying the topics and desired presentation time so that appropriate arrangements can be made. The Working Group will receive oral statements on topics relevant to its purview at an appropriate time chosen by the Chairman of the Working Group.

(c) Further information regarding topics to be discussed, whether the meeting has been cancelled or rescheduled, the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by a prepaid telephone call on August 19, 1976 to the Office of the Executive Director of the Committee (telephone 202/634-1371, Attn: Mr. T. G. McCreless) between 8:15 a.m. and 5:00 p.m., EDT.

(d) Persons with agreements or orders permitting access to proprietary information may attend portions of ACRS meetings where this material is being discussed upon confirmation that such agreements are effective and relate to the material being discussed.

The Executive Director of the ACRS should be informed of such an agreement at least three working days prior to the meeting so that the agreement can be confirmed and a determination can be made regarding the applicability of the agreement to the material that will be discussed during the meeting. Minimum information provided should include information regarding the date of the agreement, the scope of material included in the agreement, the project or projects involved, and the names and titles of the persons signing the agreement. Additional information may be requested to identify the specific agreement involved. A copy of the executed agreement should be provided to Mr. T. G. McCreless of the ACRS Office, prior to the beginning of the meeting.

(e) Questions may be propounded only by members of the Working Group and its consultants.

(f) The use of still, motion picture, and television cameras, the physical installation and presence of which will not interfere with the conduct of the meeting, will be permitted both before and after the meeting and during any recess. The use of such equipment will not, however, be allowed while the meeting is in session.

(g) A copy of the transcript of the open portion of the meeting will be available for inspection on or after August 27, 1976 at the NRC Public Document Room, 1717 H St., NW., Washington, DC 20555.

Copies of the minutes of the meeting will be made available for inspection at the NRC Public Document Room 1717 H St., NW., Washington, DC 20555 after November 22, 1976. Copies may be obtained upon payment of appropriate charges.

Dated: July 29, 1976.

JOHN C. HOYLE,
Advisory Committee Management Officer.

[FR Doc.76-22629 Filed 8-4-76;8:45 am]

ATTACHMENT A

PEAKING FACTORS WORKING GROUP MEETING
AUGUST 20, 1976
WASHINGTON, D. C.

LIST OF ATTENDEES

ACRS

W. Kerr, Chairman
J. C. Mark
J. Lee, ACRS Consultant
W. Lipinski, ACRS Consultant
T. G. McCreless*
P. Boehnert

NRC

D. Fino
M. Dunenfeld
H. Richings
S. Weiss
W. Brooks
W. F. McDonald
M. Thomas
H. Vandermolen

EXXON NUCLEAR

F. B. Skogen

NAI

B. M. Rothleder

BABCOCK AND WILCOX

H. Hassan
W. T. Brunson
C. W. Mays
D. P. Bozarth
W. J. Keyworth
M. R. Gudorf
E. J. Coppola
P. H. Klink

VEPCO

C. T. Snow
M. L. Smith
L. A. Tilai
R. W. Cross

GPU SERVICE CORP.

J. D. Luoma
J. A. Easly
T. R. Robbins

DUKE POWER

P. M. Abraham

WESTINGHOUSE

P. K. Doshn

*DESIGNATED FEDERAL EMPLOYEE

ATTACHMENT B

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WORKING GROUP ON PEAKING FACTORS
WASHINGTON, DC
AUGUST 20, 1976

\- Topics For Discussion -

1. Description of B&W reactors including incore and excore nuclear instrumentation.

2. Control techniques for B&W plants - Rodded plants and Feed and Bleed plants.

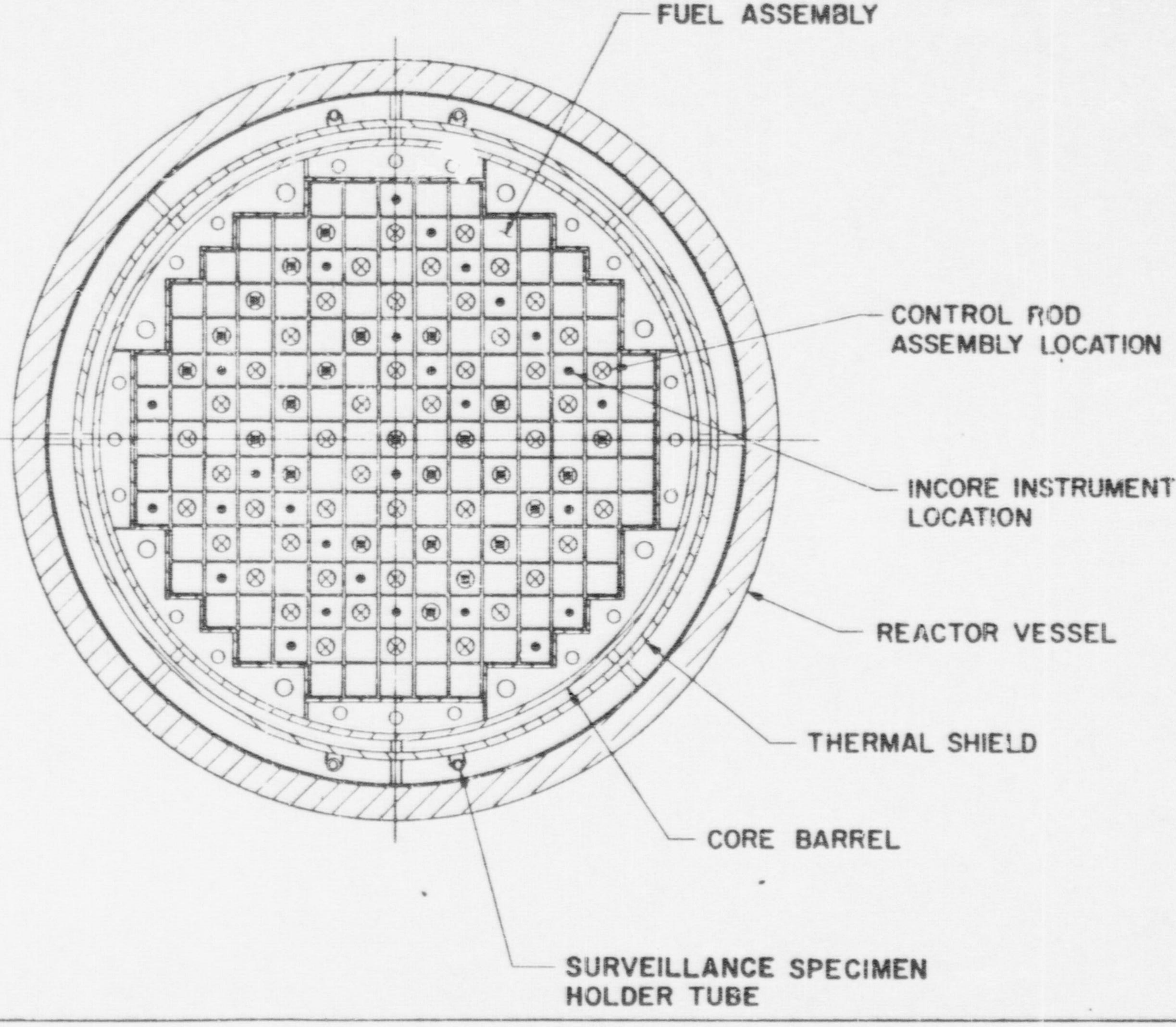
3. Control of power distribution during operation. Technical Specifications.

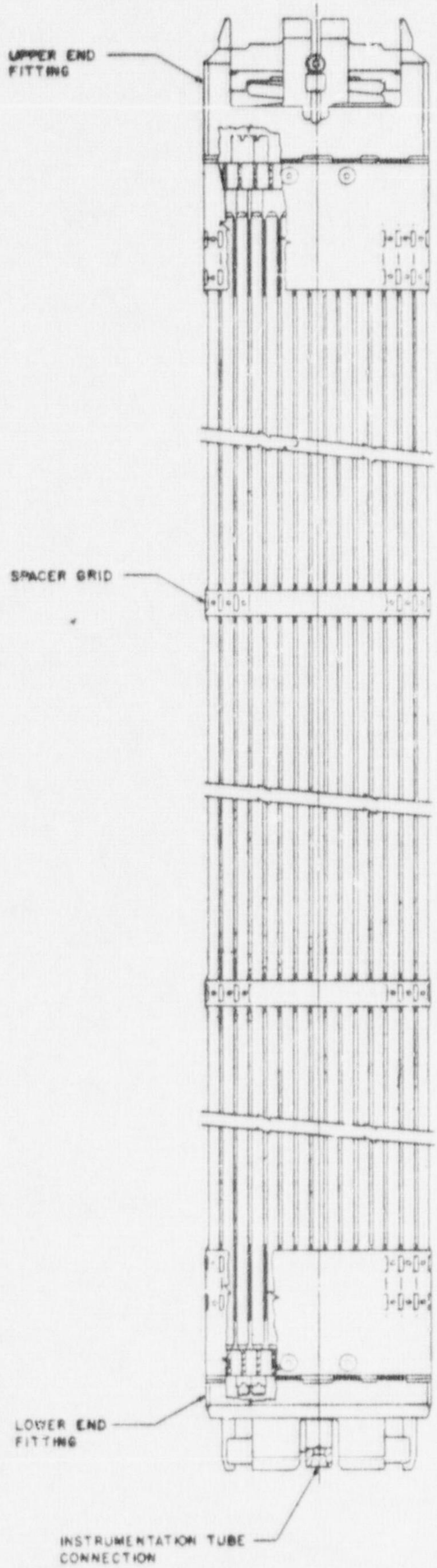
4. Methods for power distribution determination.

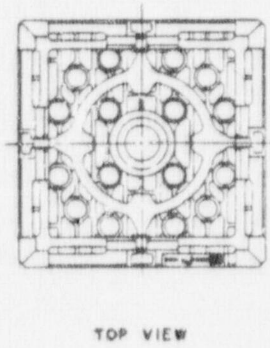
5. Uncertainties in calculation and in measurement and control.

ATTACHMENT C

ATTACHMENT D-1







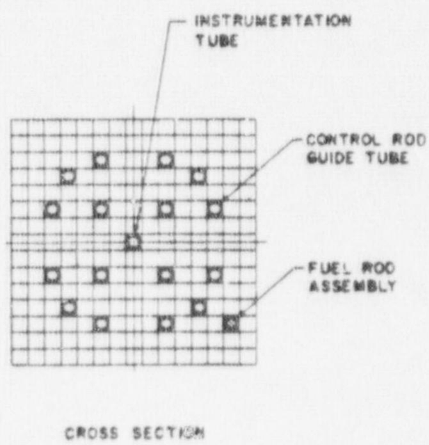
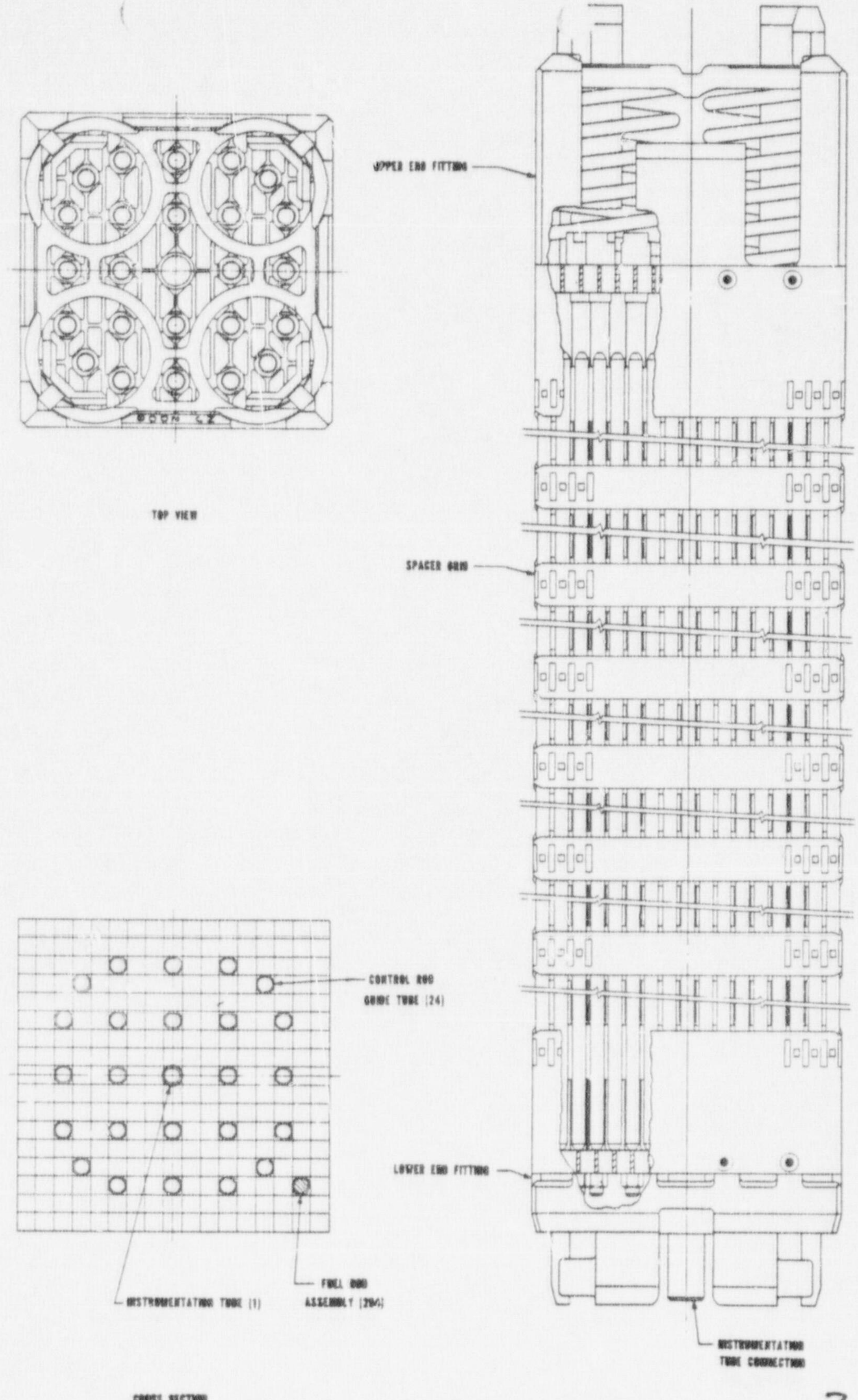
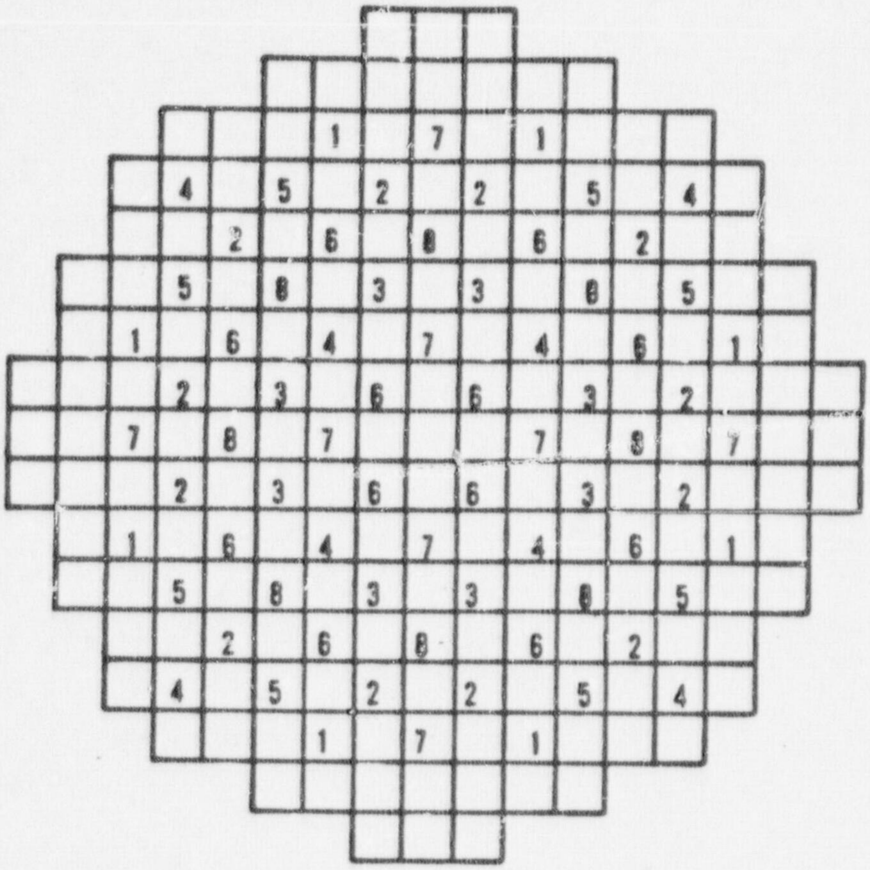


FIGURE 3.2-50
FUEL ASSEMBLY



3

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 1 Preliminary Safety Analysis Report	MARK C FUEL ASSEMBLY
	FIG. 4.2-1



GROUP NO.	PURPOSE	NO. OF RODS
1	Safety	8
2	Safety	12
3	Safety	8
4	Safety	8
5	Regulating	8
6	Regulating	12
7	Regulating	8
8	APSR A	8
	Total	72

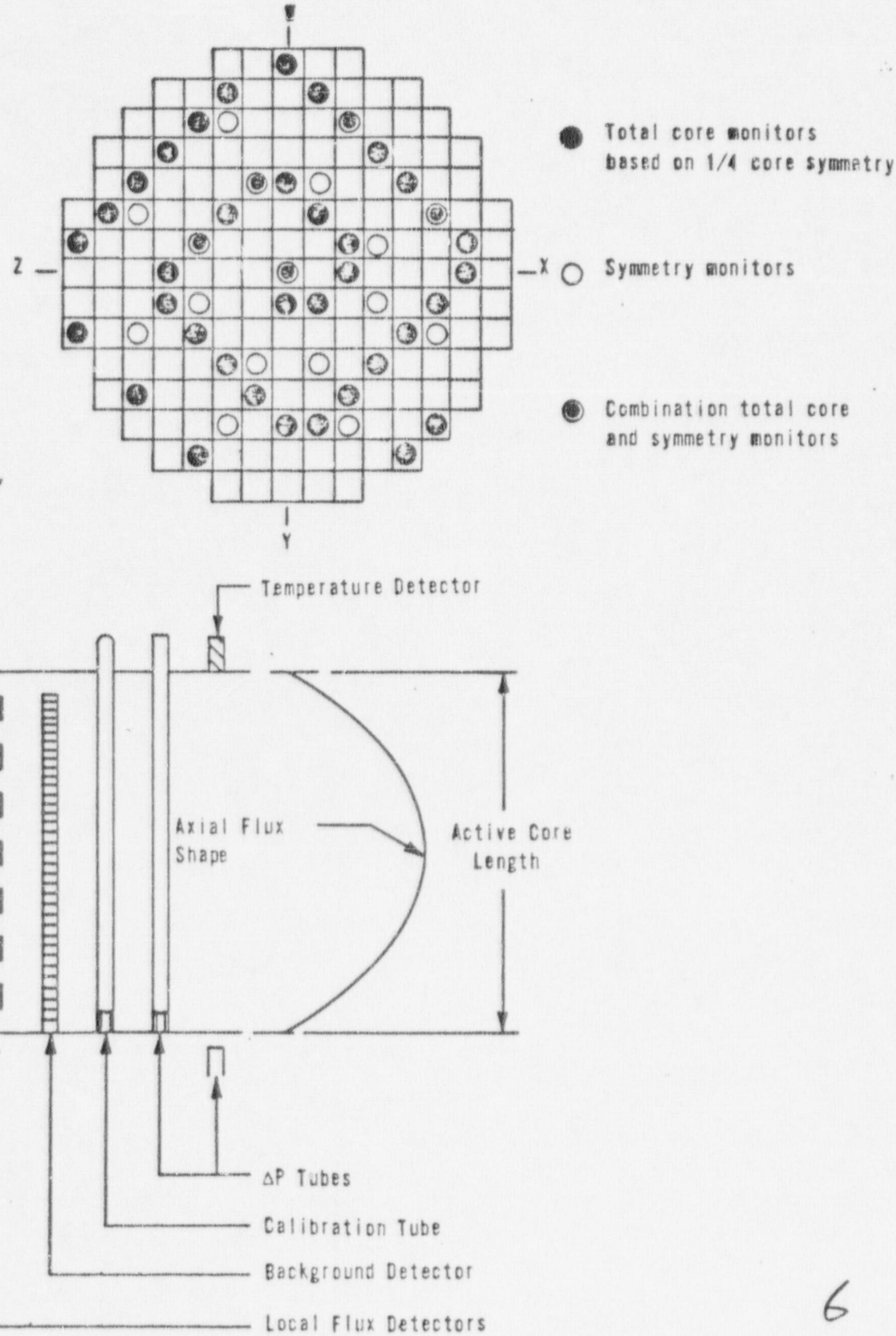
Fig. 4.3-28 CRA Patterns for Cycle 1

Table 3-1. Rod Index Vs Operating Bank Withdrawal

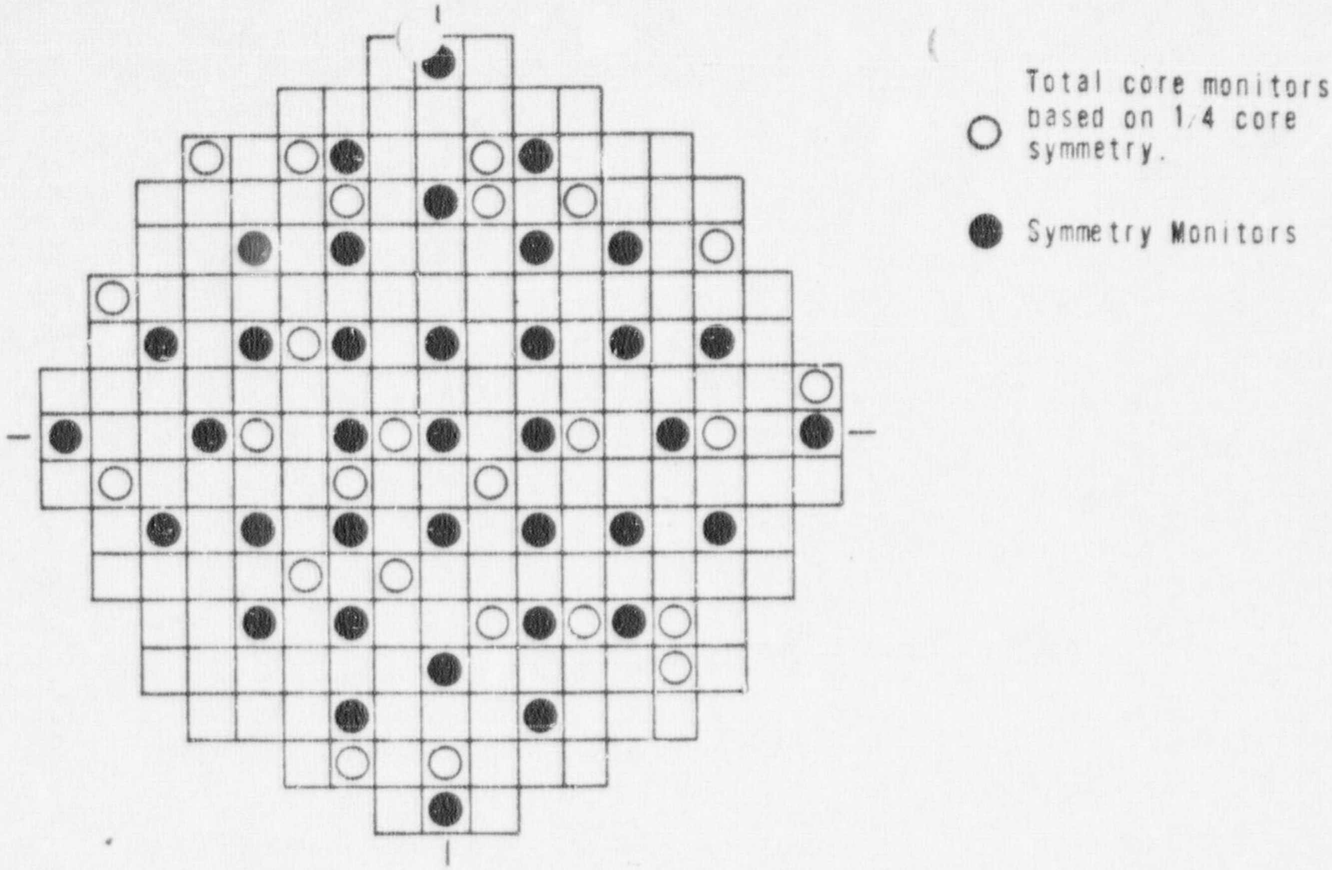
Rod index, %	Group 5 withdrawal, %	Group 6 withdrawal, %	Group 7 withdrawal, %
300	100	100	100
275	100	100	75
250	100	100	50
225	100	100	25
200	100	87.5	12.5
175	100	75	0
150	100	50	0
125	100	25	0
100	87.5	12.5	0
75	75	0	0
50	50	0	0
25	25	0	0
0	0	0	0

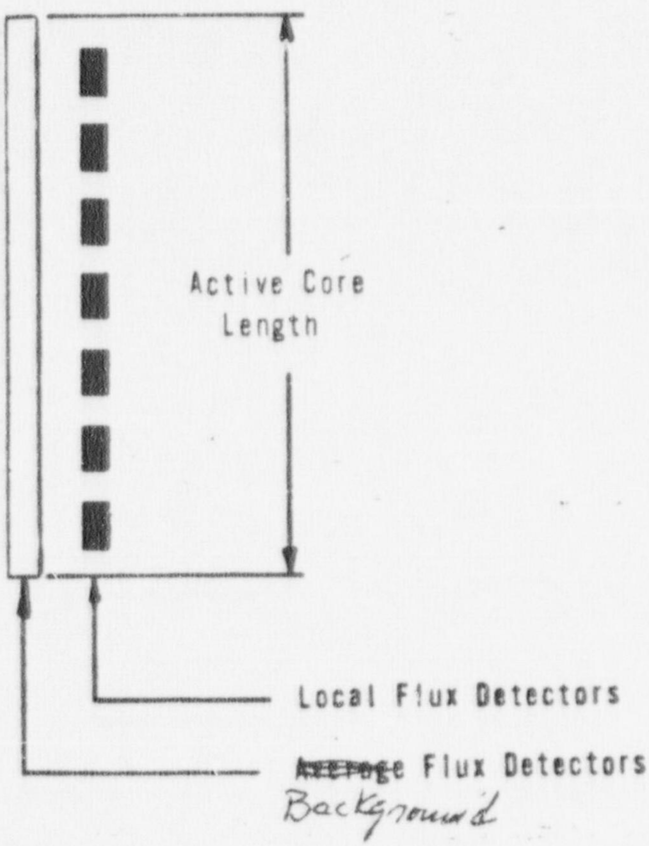
5

Figure 1-8. Incore Detector Locations



6





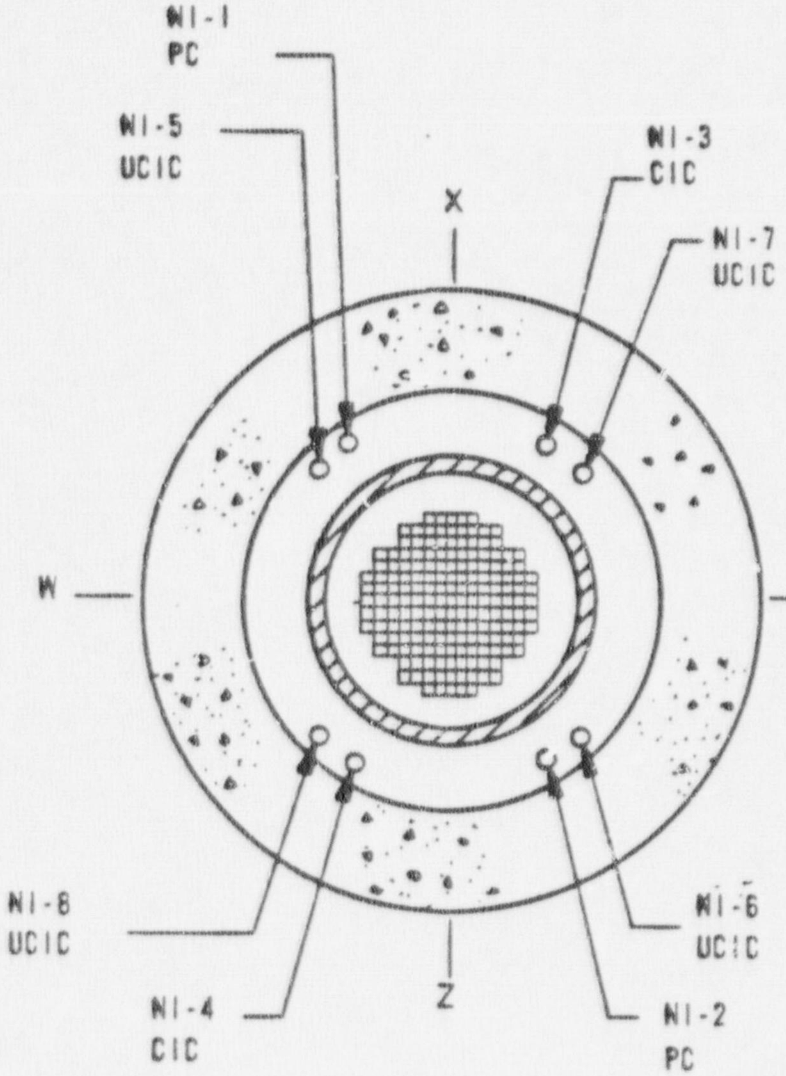
7

Fig. 7.8-4 Incore Detector Locations

PARAMETERS ACCOUNTED FOR IN THE
CONVERSION OF FLUX SIGNAL TO POWER:

- ENRICHMENT
- BURNUP
- CONTROL RODS
- BORON CONCENTRATION
- MODERATOR TEMPERATURE
- LBP CONCENTRATION

LBP



LEGEND:

PC - PROPORTIONAL COUNTER - SOURCE RANGE 1 DETECTOR

CIC - COMPENSATED ION CHAMBER - INTERMEDIATE RANGE DETECTOR

UCIC - UNCOMPENSATED ION CHAMBER - POWER RANGE DETECTOR

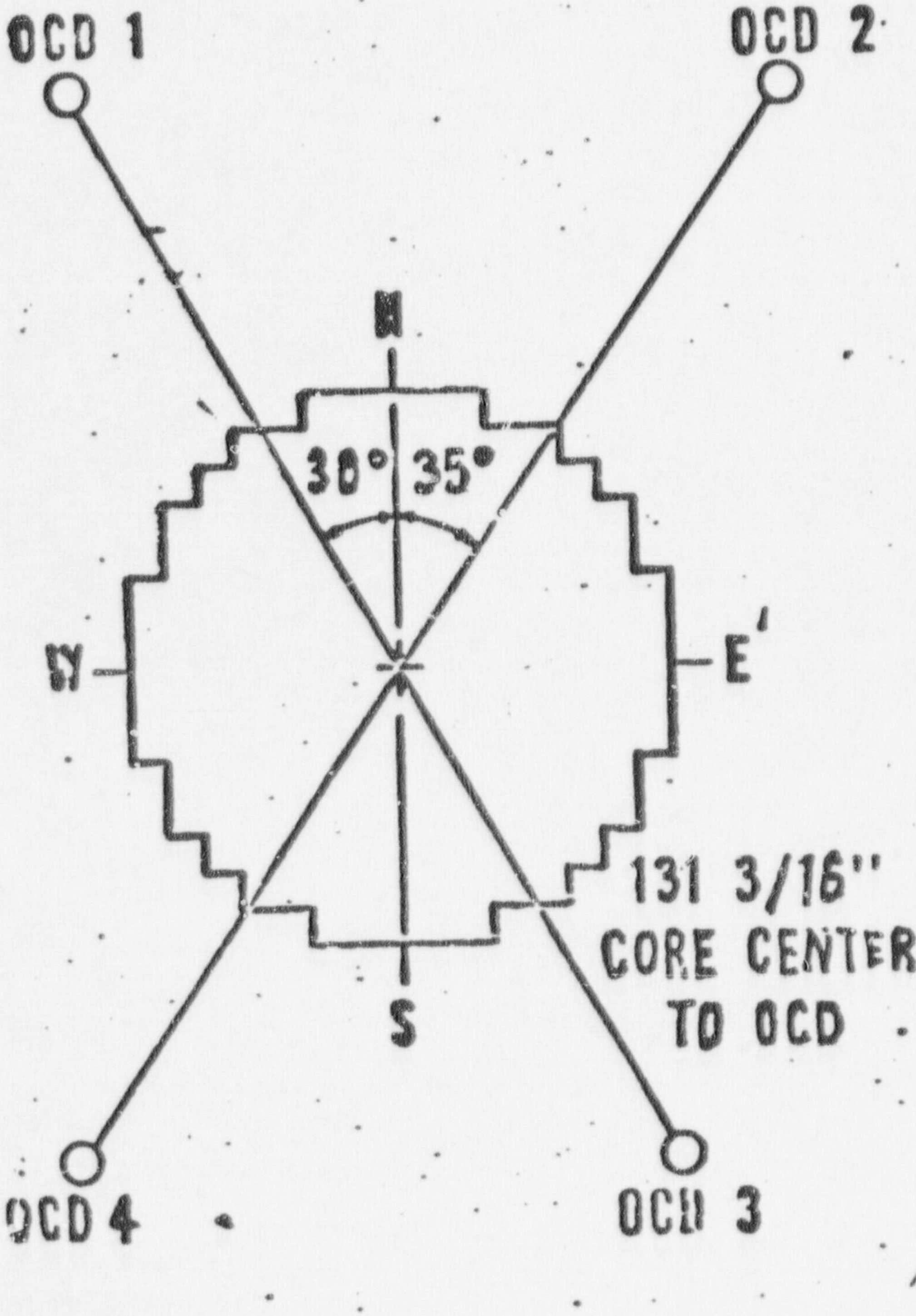
NUCLEAR INSTRUMENTATION DETECTOR LOCATIONS

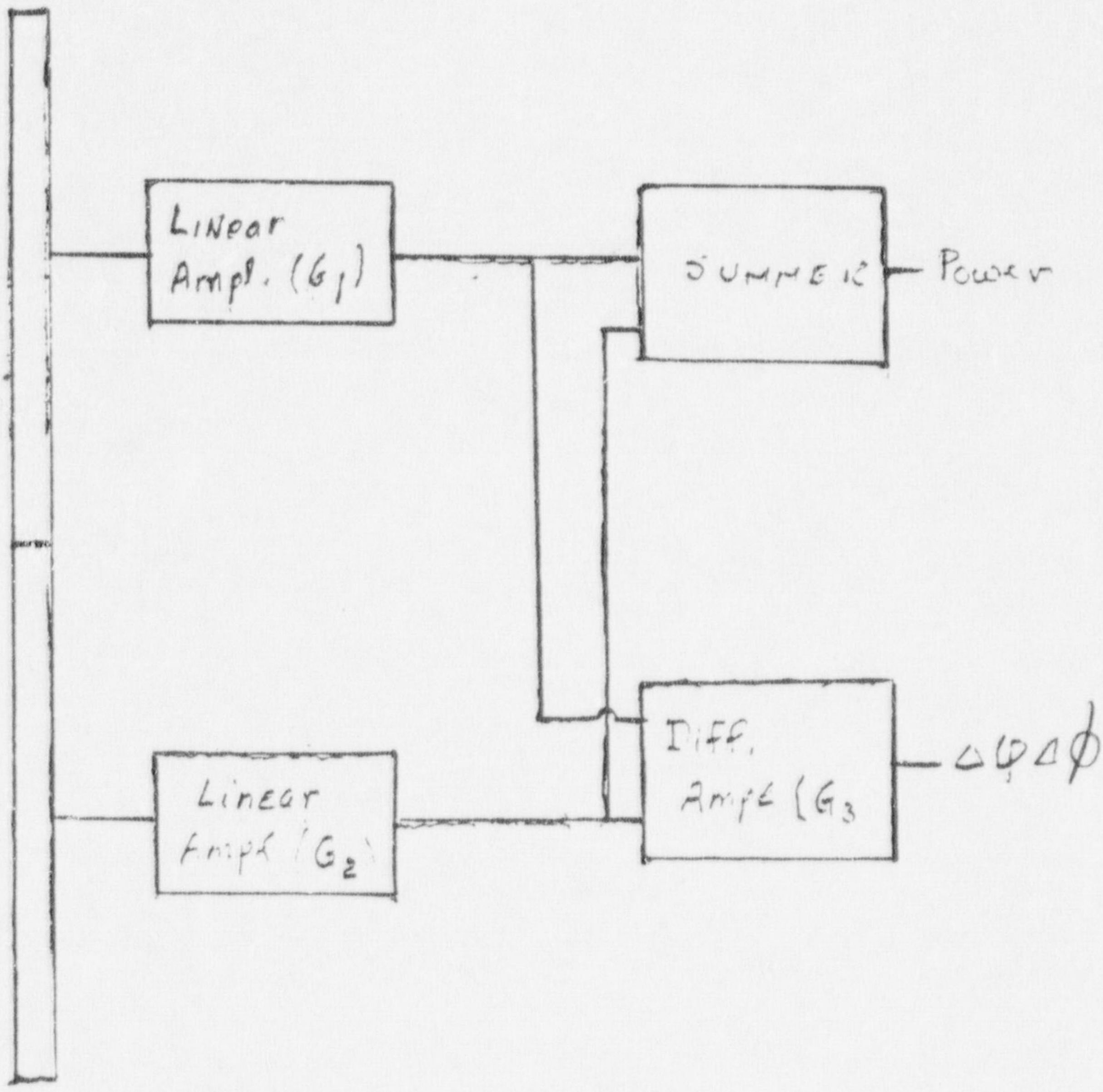
9

Figure 7.8-3

RADIAL TILT

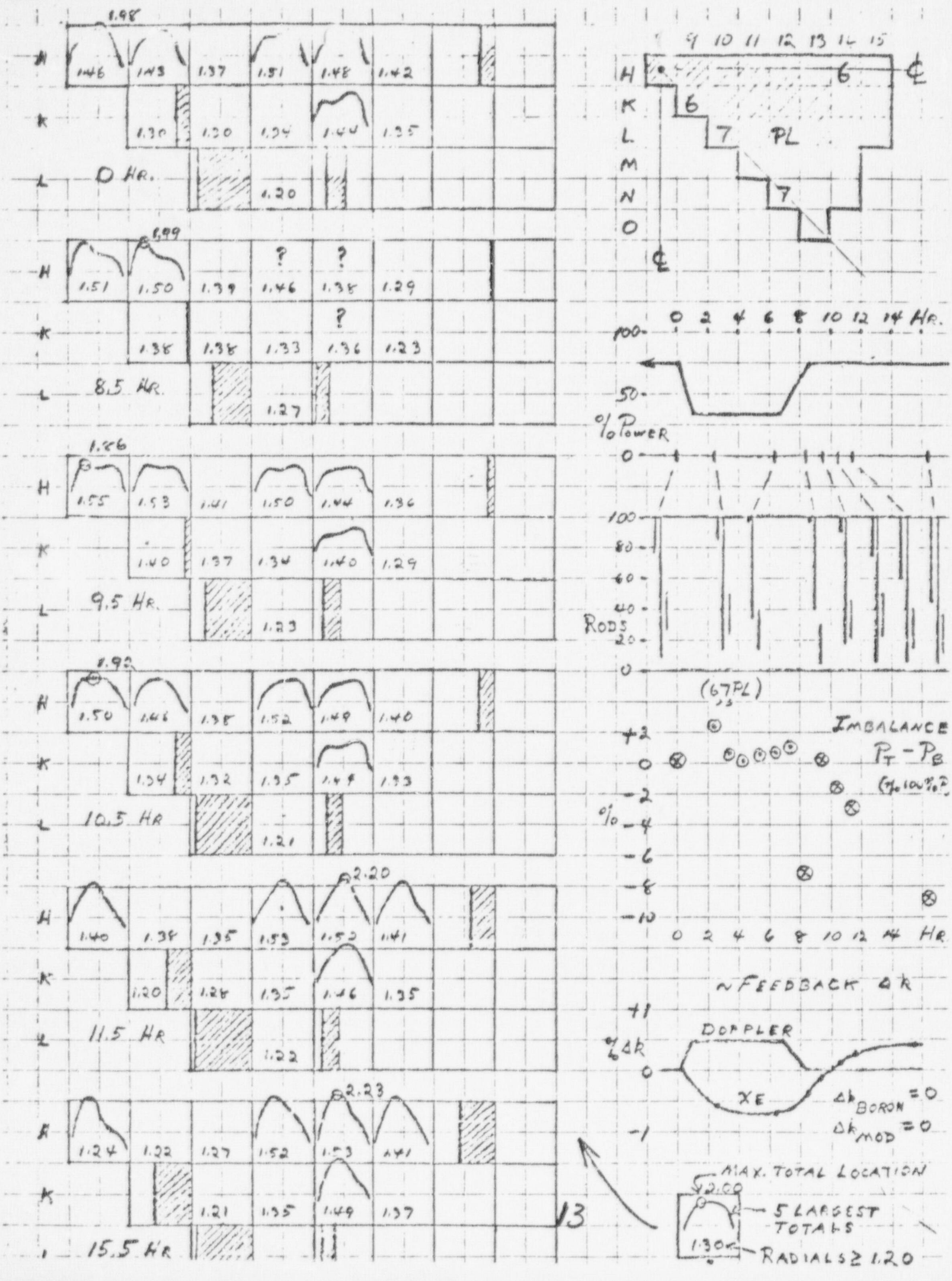
OUT OF CORE DETECTOR POSITIONS




Linear
Ampl. (G1)
SUMMER
Power
Linear
Ampl (G2)
Diff.
Ampl (G3
ΔφΔϕ

Reactivity Control Distribution

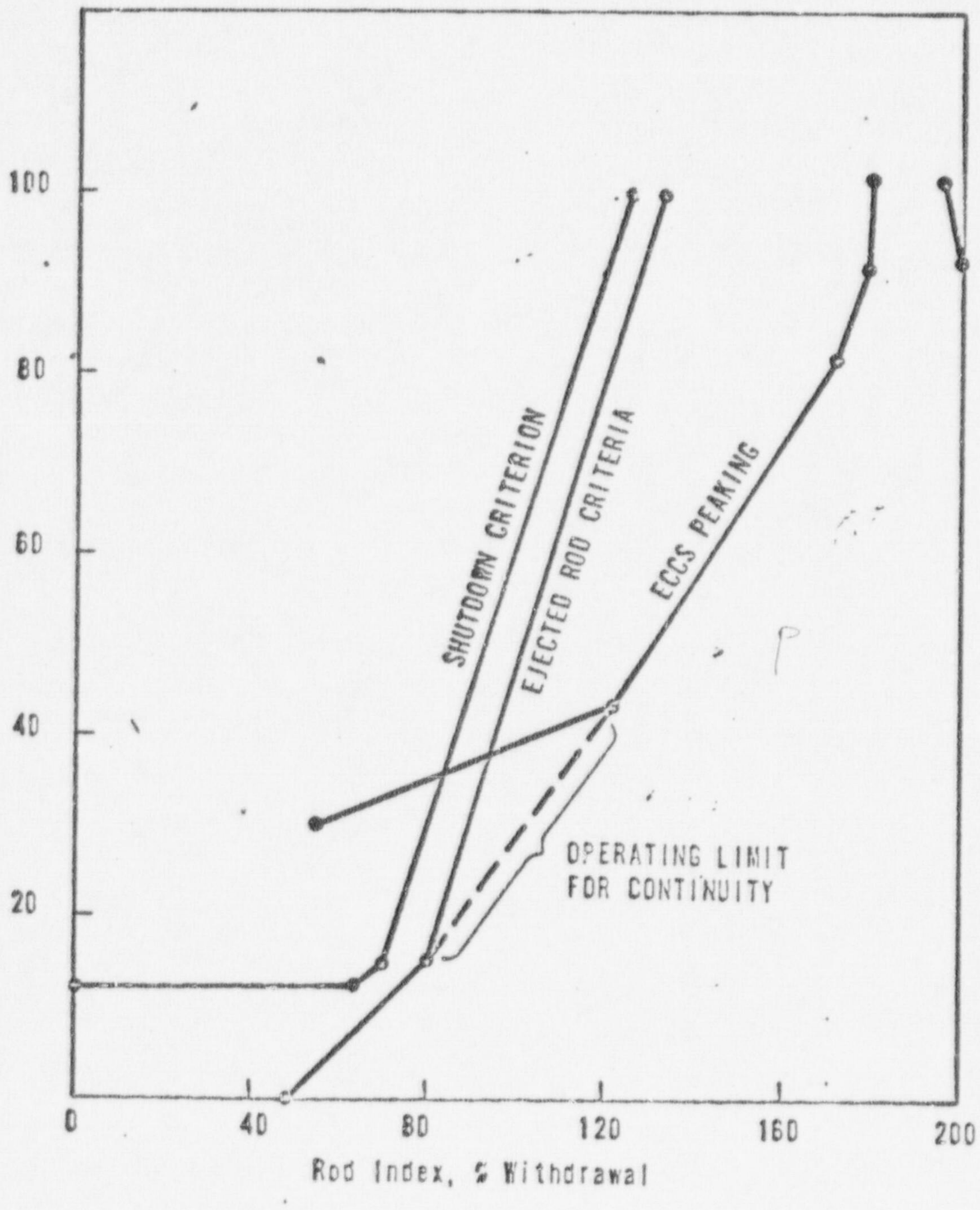
	Rodded	Bleed & Feed
Moderator Temperature Deficit (Ambient to HZP)	Boron	Boron
Equilibrium Xe and Sm	Boron	Boron
Burnup and Fission Product Buildup	Boron + LBP	Boron + LBP
Transient Xenon	CRA	Boron
Doppler Deficit (0 to FP)	CRA	CRA
Moderator Deficit (HZP to HFP)	CRA	CRA

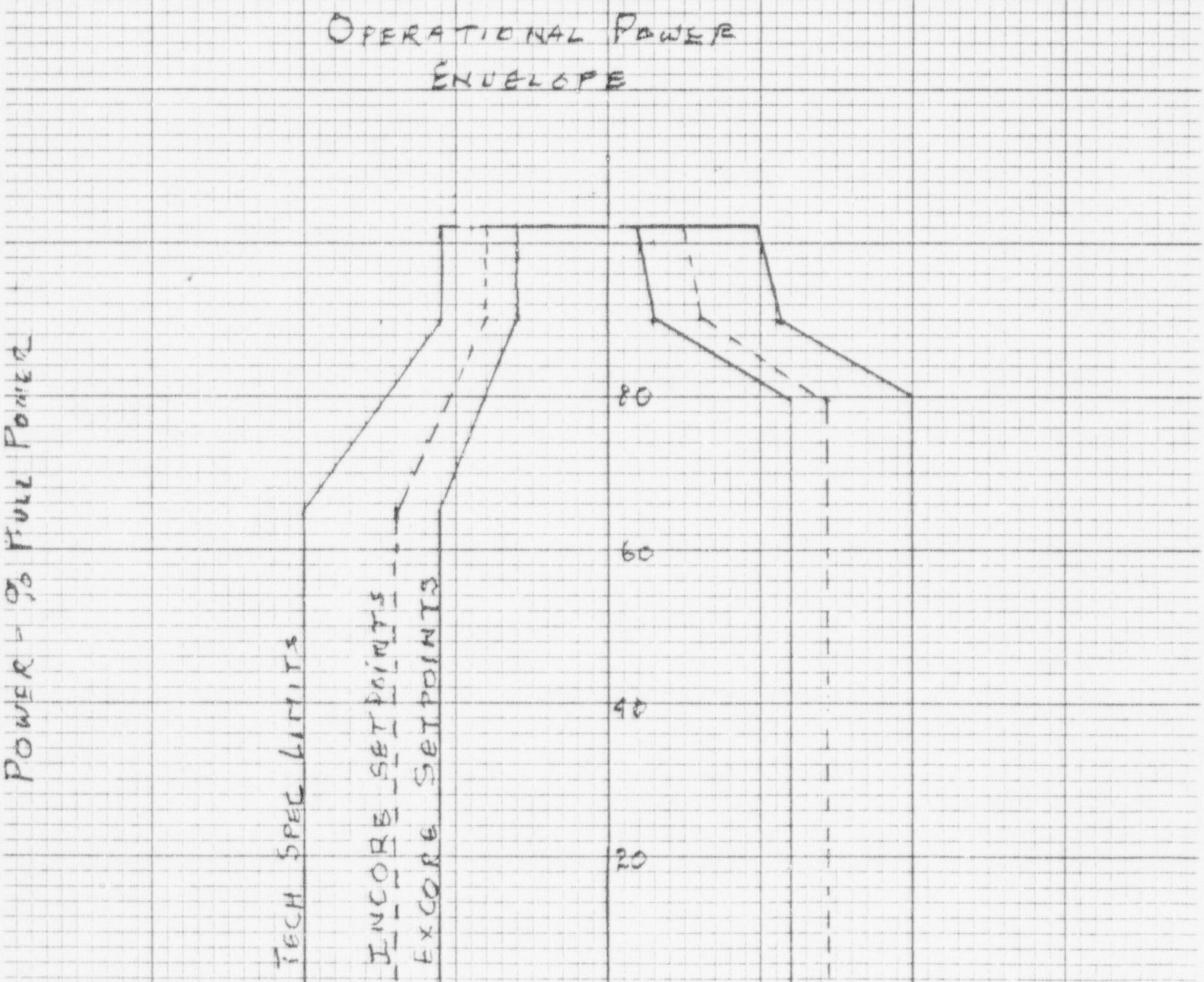


0 HR.
1.98
1.46 1.43 1.37 1.51 1.48 1.42
1.30 1.30 1.34 1.44 1.35
1.20
8.5 HR.
1.99
1.51 1.50 1.39 1.46 1.38 1.29
1.38 1.38 1.33 1.36 1.23
1.27
9.5 HR.
1.86
1.55 1.53 1.41 1.50 1.44 1.36
1.40 1.37 1.34 1.40 1.29
1.23
10.5 HR
1.92
1.50 1.46 1.38 1.52 1.49 1.40
1.34 1.32 1.35 1.49 1.33
1.21
11.5 HR
2.20
1.40 1.38 1.35 1.53 1.52 1.41
1.20 1.28 1.35 1.46 1.35
1.22
15.5 HR
2.23
1.24 1.22 1.27 1.52 1.53 1.41
1.21 1.35 1.49 1.37
H K L M N O
9 10 11 12 13 14 15
6 6 7 PL 7
℄
0 2 4 6 8 10 12 14 HR.
100 50
% POWER
RODS
100 80 60 40 20 0
(67PL)
IMBALANCE
$P_T - P_B$
(% 100% P)
+2 0 -2 -4 -6 -8 -10
%
0 2 4 6 8 10 12 14 HR
~FEEDBACK Δk
+1 0 -1
% Δk
DOPPLER
XE
$\Delta k_{BORON} = 0$
$\Delta k_{MOD} = 0$
MAX. TOTAL LOCATION
2.00
5 LARGEST TOTALS
1.30
RADIALS ≥ 1.20
13

FIGURE S2

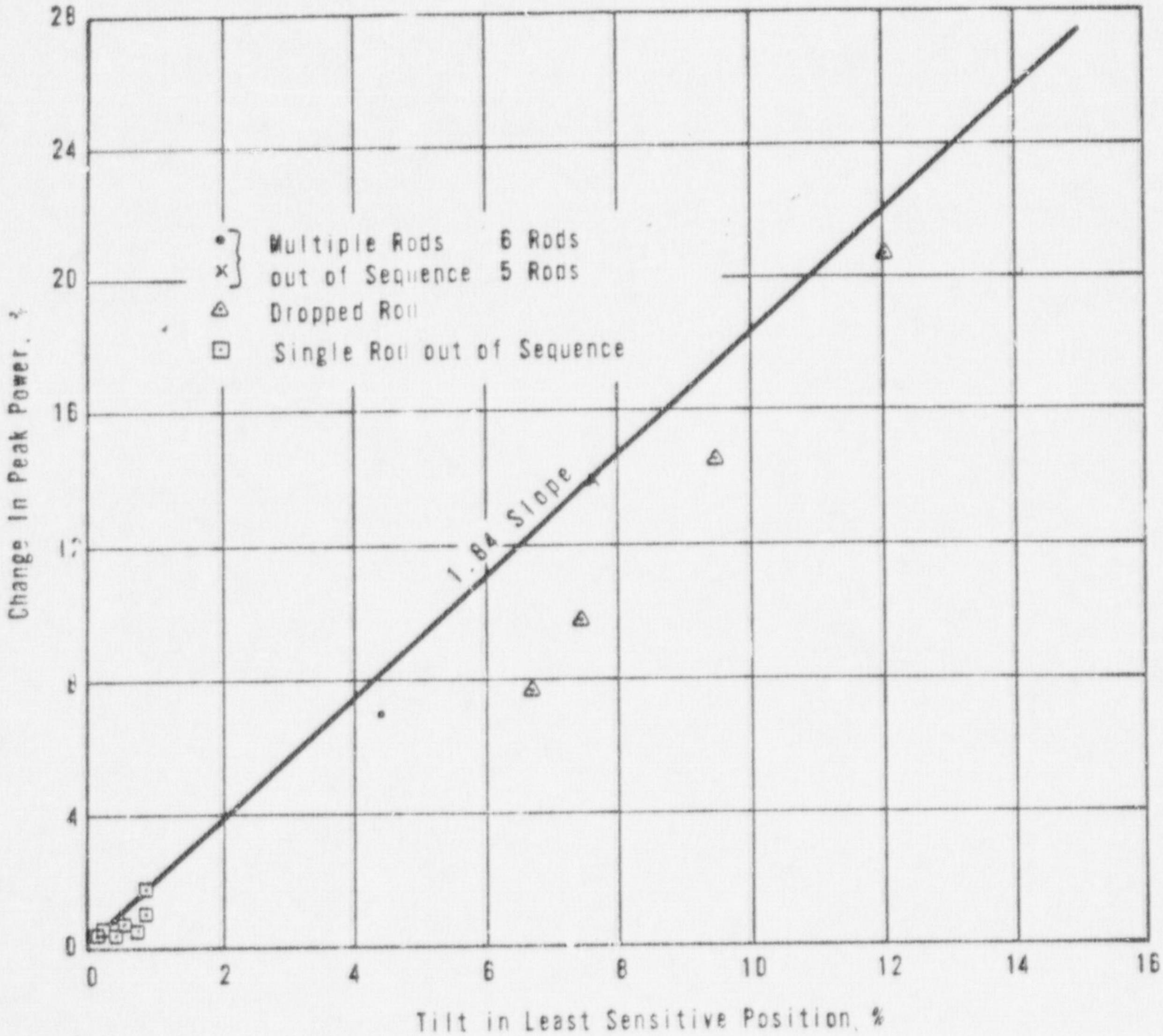
CRITERIA FOR ESTABLISHING CONTROL ROD POSITION LIMITS - RANCHO SECO, CYCLE 1




OPERATIONAL POWER
ENVELOPE
POWER - % FULL POWER
TECH SPEC LIMITS
INCORE SETPOINTS
EXCORE SETPOINTS
80
60
40
20
-20
-10
0
10
20
CORE IMBALANCE - %

15

Figure 3-5. Percent Change in Peak Power Vs Radial Tilt



16

ALARMS

QUADRANT TILT

CONTROL ROD INSERTION

AXIAL IMBALANCE

ROD MISALIGNMENT

ALARM - 7"

POWER RUNBACK - 9"

Calculations Performed for Power Distribution Analysis

1. Full Power Equilibrium Xenon
   a. BOL
   b. 4 EFPD (Equilib Xenon)
   c. 25, 50, 75, etc EFPD
   d. Rod Interchange
2. Design Transient
   a. 100-50-100 or 100-30-100
   b. 4 EFPD, MOL, near EOL
   c. Rod Interchange
3. Off Normal Conditions
   a. APSR's over entire range
   b. Full length rods outside normal operational band

$$H(z) = P_{3\text{-}D}(z) \times RL \times AL \times S(z) \times HCF \times NUF$$

$$\times \bar{H} \times X \times QT \times RB(z) \times FOP \times 1.02 \times PLM(z)$$

$H(z)$ = Heat flux at elevation z

$\bar{H}$ = Average heat flux in densified core

$P_{3\text{-}D}(z)$ = Peaking factor at nodal elevation z from 3-D calculation

RL = Radial-local peaking factor = ratio of hot pin to nodal power

AL = Axial-local factor to account for effect of spacers

\- S(z) = Power spike factor due to densification gaps

\- HCF = Hot channel factor

\- NUF = Nuclear Uncertainty Factor

\- X = Non equilibrium Xenon penalty factor

\- QT = Quadrant tilt penalty factor

\- RB(z) = Rod bowing penalty factor

FOP = Fraction of full power

1.02 = Calorimetric Uncertainty factor

\- PLM(z) = Part length rod mismanagement factor

Radial Local Peaking Factor

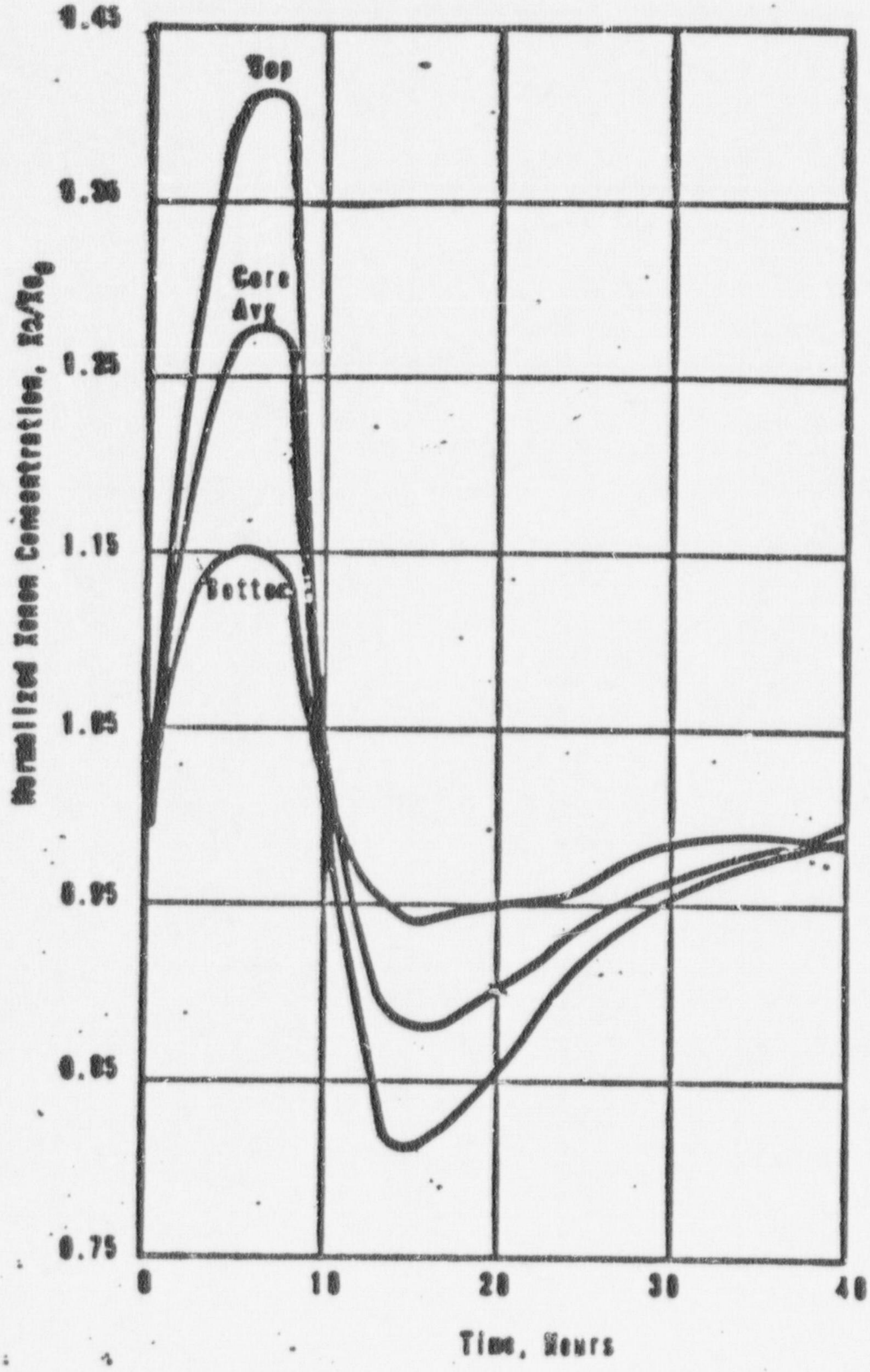
Function of:

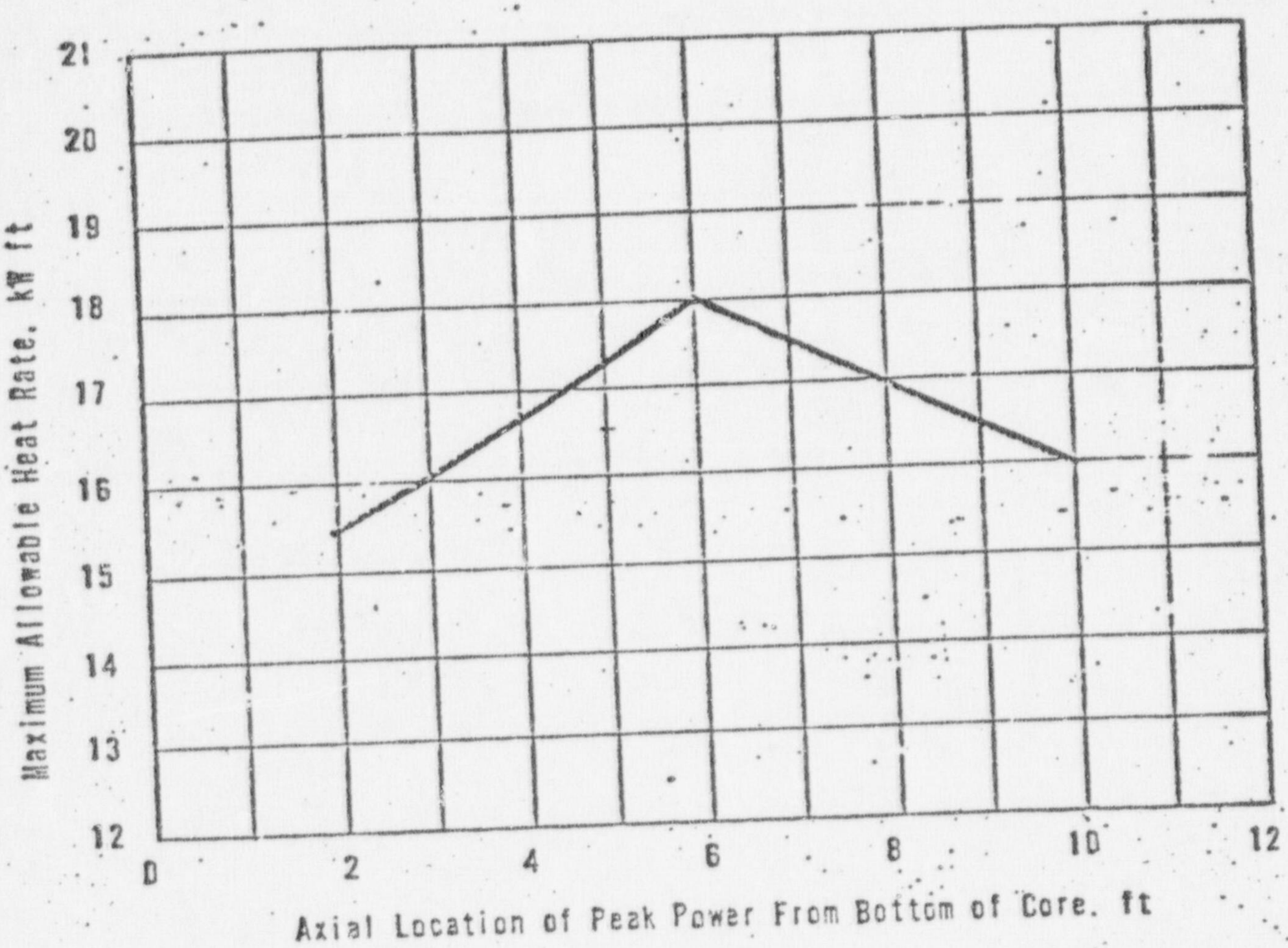
- Fuel Type
  - Enrichment
  - LBP distribution and B_4C concentration
- Burnup
- Controlled or Uncontrolled
- Position in Core

Calculated by detailed two dimensional quarter Core PDQ calculation

Conservative Envelope of Values used in design

Transient Xenon During the Design Power Maneuver (BOL)





LOCA LIMITED MAXIMUM ALLOWABLE
LINEAR HEAT RATE

Figure 3.5-2E

Procedures for Establishing Operating Limits

1. At each level in the core plot maximum heat generation rate as a function of rod insertion

2. Compare curve to allowable heat generation rate at that elevation to obtain range of rod insertion permitted

3. Repeat for each core level

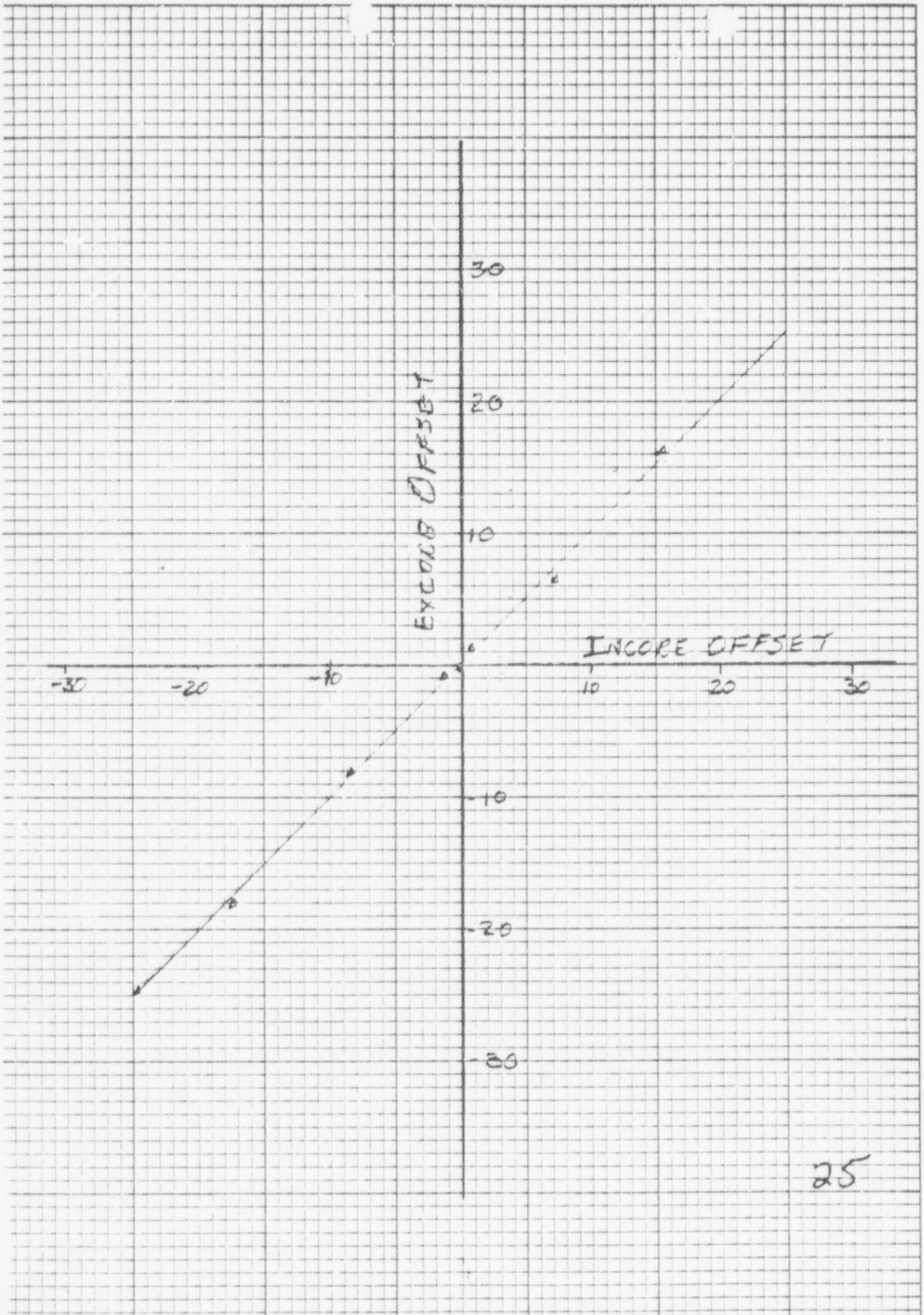
4. Obtain most restrictive rod insertion range.

Measurement Uncertainties

1. Incore Instrumentation
   1. Instrument Uncertainty
   2. Electronics Uncertainty
   3. Point Measurement to Nodal Power

2. Excore Instrumentation
   1. Instrument Uncertainty
   2. Electronics Uncertainty

3. Incore to Excore Correlation
   1. Axial Imbalance
   2. Quadrant Tilt
   3. Calibration Tolerance



K&E 10 X 10 TO THE INCH 47 0700
10 X 15 INCHES
KEUFFEL & ESSER CO.

B&W Topical Reports on Calculation Methods and Power Distribution

✓BAW-10111 "Summary Description of the Babcock and Wilcox Integrated Nuclear Design System", March, 1976

BAW-10112 "ETOGM - Epithermal Cross Section Generation Code Using ENDF/B Data" October, 1975

BAW-10113 "THOR - Thermal Cross Section Generation Code Using ENDF/B Data" October, 1975

BAW-10114 "PROLIB - Code to Create Production Library of Nuclear Data for Design Calculations" October, 1975

✓BAW-10115 "NULIF - A Neutron Spectrum Generator, Few Group Constant Calculator and Fuel Depletion Code" June, 1976

BAW-10116 "Assembly Calculations and Fitted Nuclear Data" (to be published)

BAW-10117 "B+W Version of PDQ07- Users Manual" October, 1975 (Proprietary Version BAW-10117P)

✓BAW-10118 "Core Calculations – Techniques and Procedures" (to be published December, 1976)

BAW-10119 "Power Peaking Uncertainity" (to be published September, 1976)
✓

BAW-10120 "Comparison of Core Physics Calculations with Measurements" (to be published April, 1977)

BAW-10121 "Reactor Protection System Limits and Set Points" (to be published January 1977)
✓

BAW-10122 "Normal Operating Controls" (to be published
✓

BAW-10123 "Incore Instrumentation System" (to be published June, 1977)
✓

BAW-10124 "FLAME – A Three-Dimensional Nodal Code for Calculating Core Reactivity and Power Distribution" January 1976

BAW-10125 "Verification of the Three-Dimensional FLAME Code", March, 1976

BAW-10078 "Operational Parameters for B&W Rodded Plants, September 1973 (Proprietary)

BAW-1401 "Davis Besse Unit 1 Fuel Densification Report", April 1975 (Proprietary)

TZG 73-47 Operational Parameters for Rancho Seco Unit 1", October 1973, (Proprietary)

Docket STN 50-561 B-SAR-205 PSAR Section 4.3, including ammendment 2