Relaxation of Constant Axial Offset Control

(Part A of NS-EPR-2649)

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Table of Contents

Table of Contents

I. RAOC -- AN EXTENSION OF CAOC

A. REVIEW OF CONSTANT AXIAL OFFSET CONTROL (CAOC)

WCAP-8385 (Proprietary) and WCAP-8403 (non-Proprietary), "Power Distribution Control and Load Following Procedures," developed the methodology and described the procedure needed for plant operation to insure peaking factors below accident analysis limits. The Constant Axial Offset Control (CAOC) strategy developed in this topical report insures peaking factor and DNB limits are satisfied by maintaining the axial power distribution within a $\pm 5\%$ ΔI band around a measured target value. By controlling the axial power distribution, the possible skewing of the axial xenon distribution is limited, thus minimizing xenon oscillations and their effects on the power distribution.

This topical report described two modes of operation: operation with part length (PL) rods (Mode B) and operation without PL rods (Mode A). It was demonstrated generically that a LOCA peaking factor of 2.32 could be met at all times, and plant specific analyses were required only if the F_Q limit was less than this generic value or generic radial peaking factor limits were not met. A typical ΔI band is shown in Figure I-1.

B. ΔI BAND WIDENING STUDIES

Plants have varying degrees margin to Design Bases Limits which can be converted into operating flexibility in the form of a wider ΔI band. Several "standard" widened ΔI bands are available with the two most common being +6, -9% and +3, -12%. A typical widened ΔI band is shown in Figure I-2 with respect to the standard ΔI band.

C. RELAXED AXIAL OFFSET CONTROL (RAOC)

Typically in plants with relatively high LOCA F_Q limits, some margin to the LOCA limit still remains even after one of the standard band widening studies is performed. This is evidenced in Figures I-3 and

I-4. Fiqure I-3 is the $F_Q \cdot P$ vs. core height plot from a reload cycle using the standard $\pm5\%$ ΔI band. Figure I-4 is a similar plot using a +6, -9% ΔI band. While the +6, -9% ΔI band increases peaking factors relative to the $\pm5\%$ ΔI band, margin still exists to the LOCA limit. This indicates that the ΔI band could be widened by some additional amount. The RAOC methodology eliminates the iterative process of searching for this wider band by determining the allowed band directly.

The allowed ΔI band can additionally be widened further at reduced power levels. This is evidenced by two pieces of data. First, current Standard Technical Specifications allow ΔI to be outside the allowed band for up to one hour in 24 between 50 and 90% power and two hours in 24 below 50% power. In fact, the current Technical Specifications do not require CAOC operation below 50% at all as long as power is not increased above 50% until CAOC requirements are met. Secondly, all the limiting F_Q values calculated using the current analysis (such as those shown in Figure I-3 and I-4) are a result of full power operation. Since the limit is based on $F_Q \cdot P$ this indicates that power decreases faster than F_Q increases during CAOC operation and therefore indicates that larger axial peaking factors, and hence wider ΔI limits, are permissible at reduced power levels. The RAOC methodology also determines this permissable part power relaxation directly. A typical RAOC limit is shown in Figure I-5 with respect to the standard and widened CAOC ΔI bands.

Because relaxation of the CAOC Technical Specifications is much sought after by utilities, the RAOC methodology has been developed. This methodology makes it possible to obtain the necessary and sufficient requirements to satisfy the safety limits under all operating conditions. The advantages of RAOC operation are to:

a) Allow the operator to minimize and/or smooth the boron system duty relative to CAOC operation,

b) Increase spinning reserve capacity during Mode A operation,

c) Reduce rod motion corrections and hence operator action required to maintain conformance with power distribution control Technical Specifications,

d) Increase greatly the ability to return to power after a plant trip.

In actual plant operation, the surveillance requirements to verify RAOC conformance to the F_Q limits can take two forms. First, $F_{xy}(z)$ can be measured, as in the current Standard Technical Specifications, to verify the values used in the analysis. Second, $F_Q(z)$ can be measured directly and an allowance for normal operation transients, W(z), applied before $F_Q(z)$ is compared to the limit, as in the F_Q Surveillance Technical Specification.

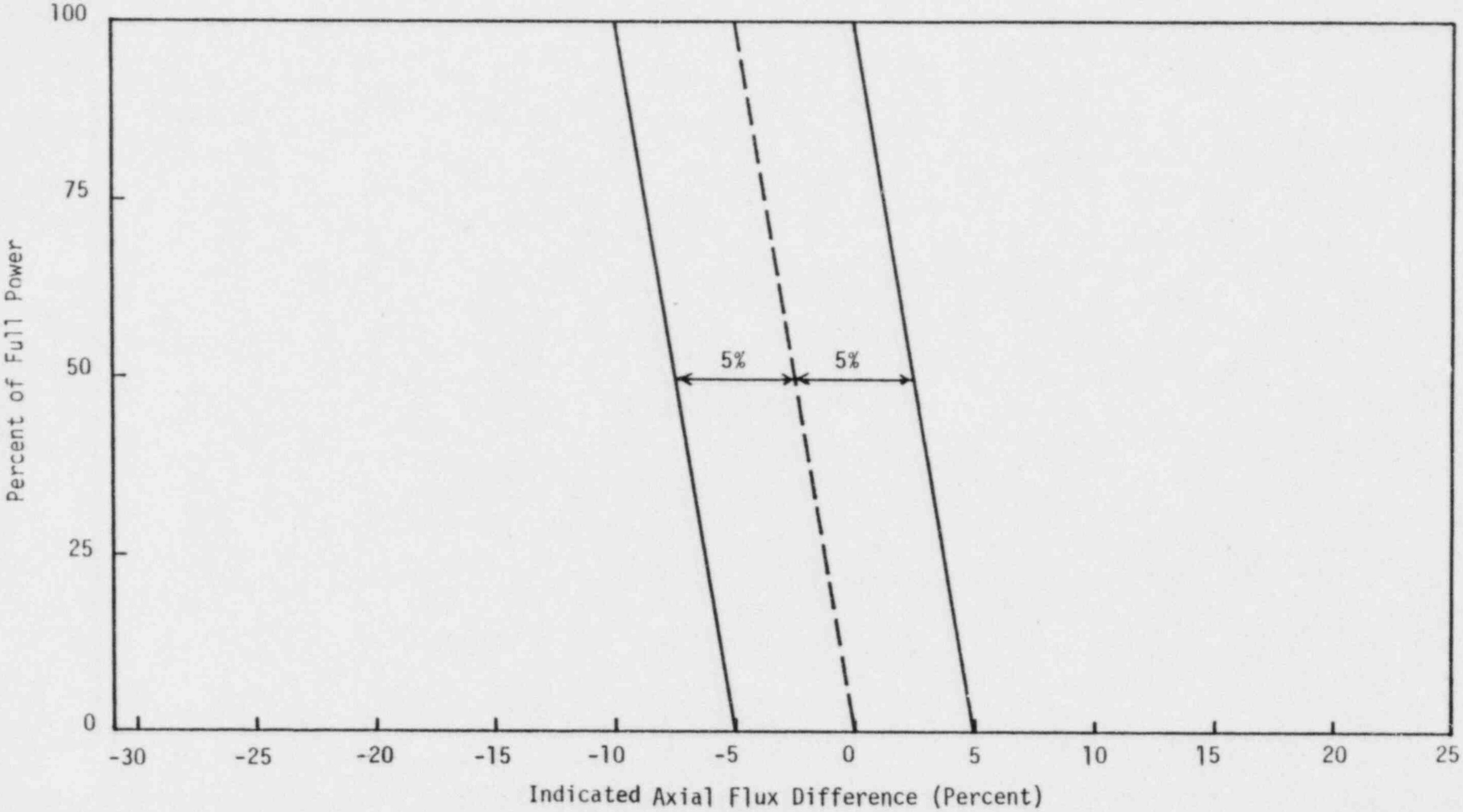


FIGURE I-1

EXAMPLE OF CAOC ± 5% ΔI BAND

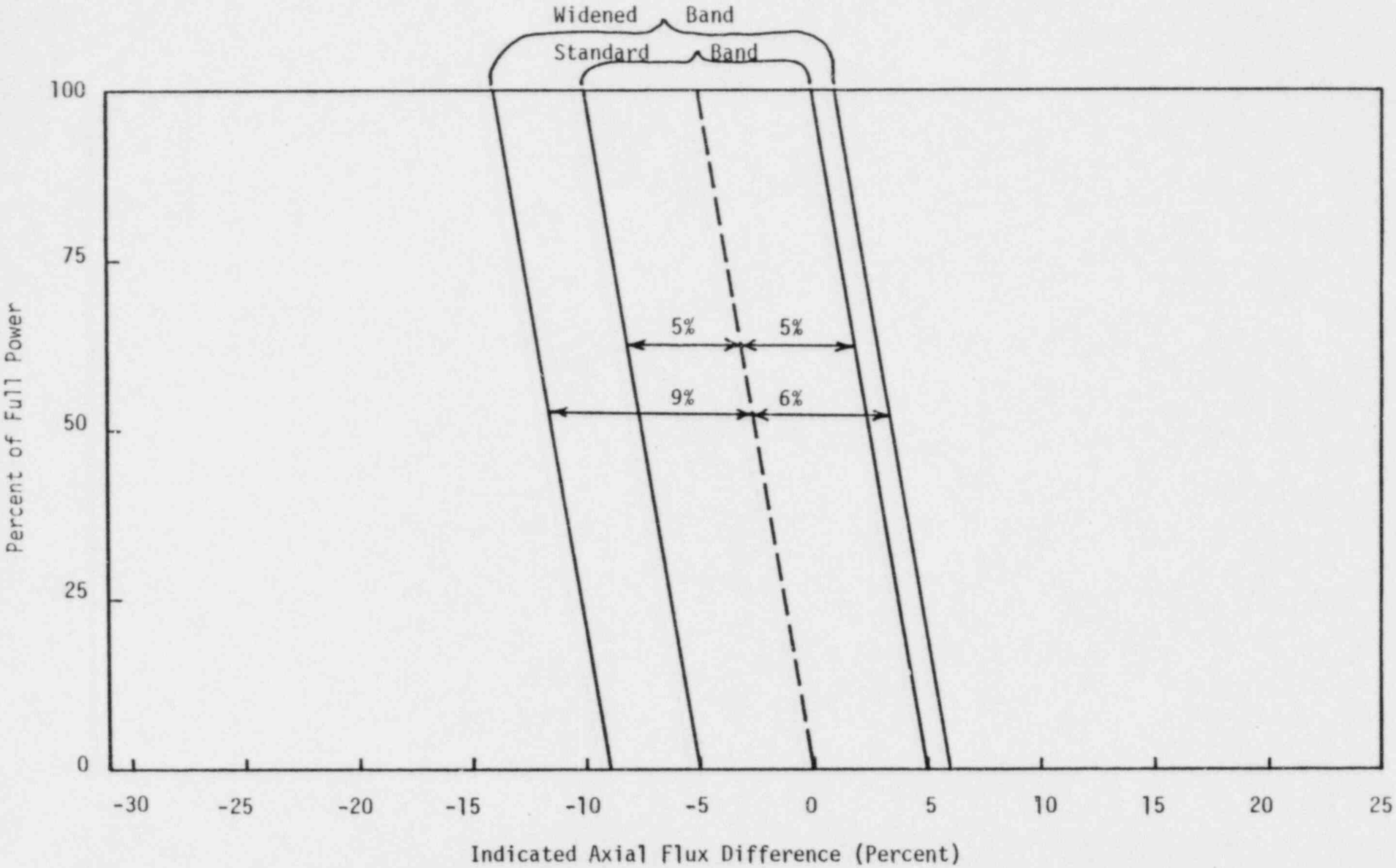


FIGURE I-2

Example of CAOC +6, -9% ΔI Band

FIGURE I-3

EXAMPLE OF MAXIMUM [$F_Q^T \cdot P_{Rel}$] VERSUS AXIAL CORE HEIGHT

DURING NORMAL OPERATION ±5% ΔI BAND

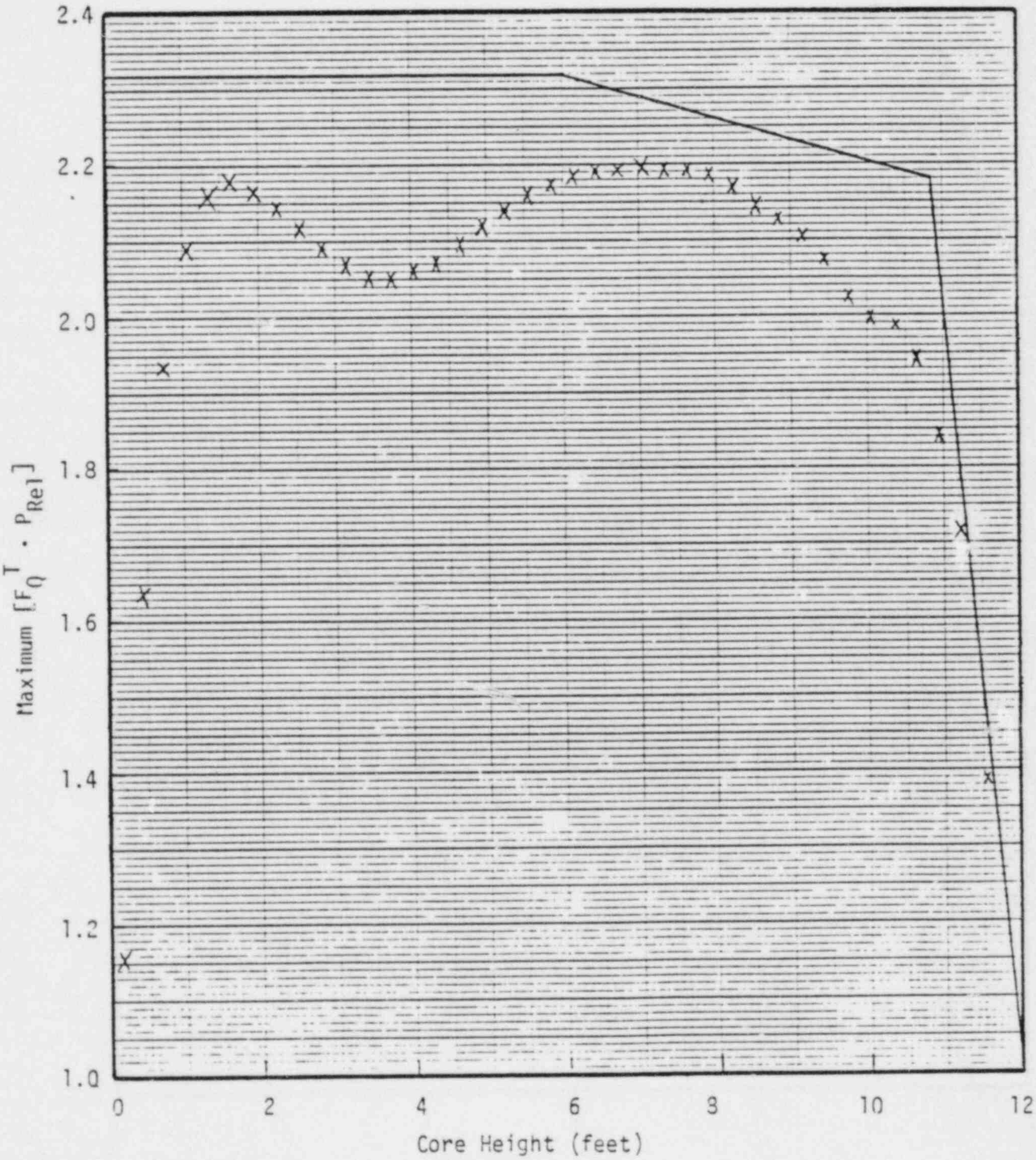
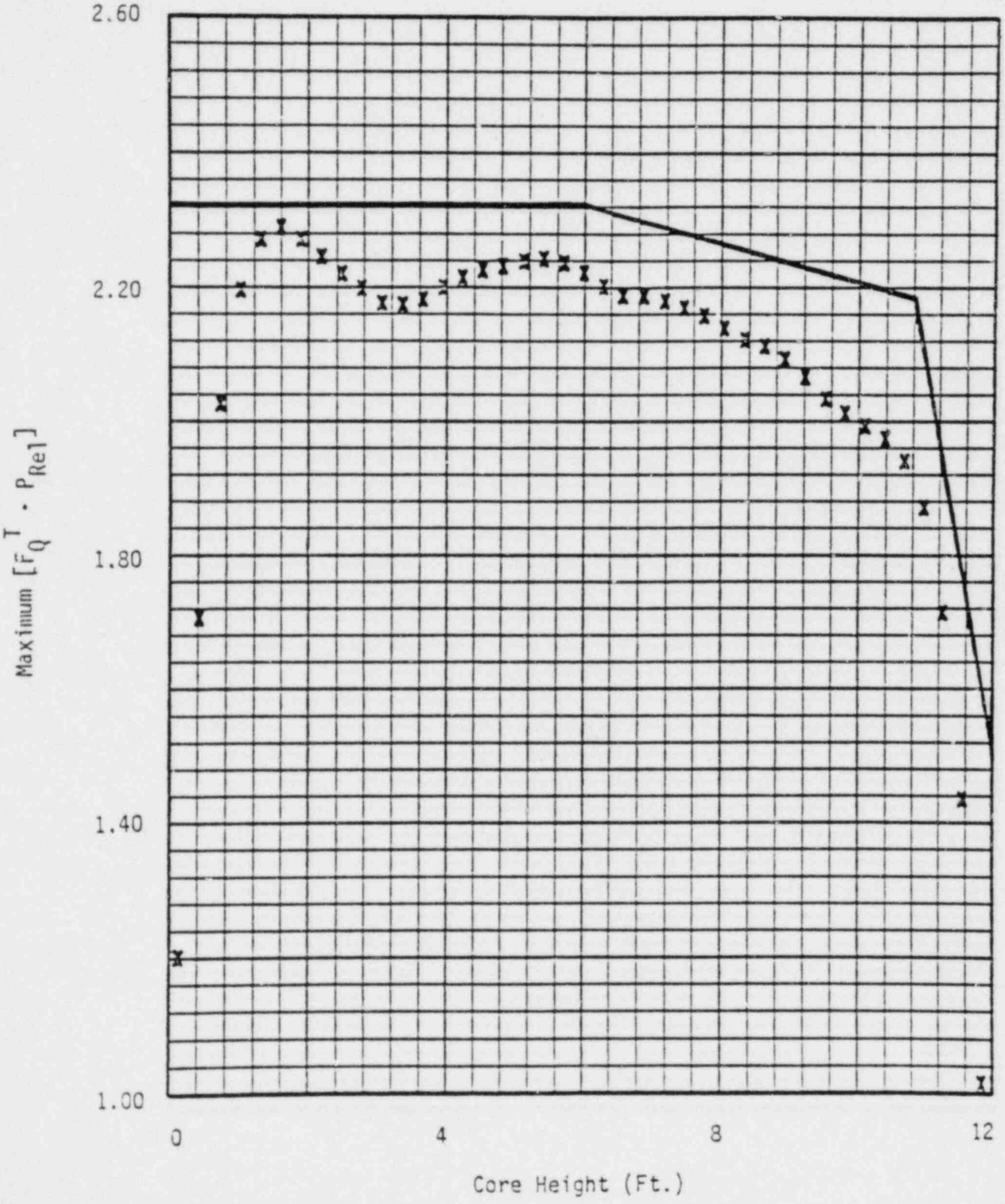


FIGURE I-4

EXAMPLE OF MAXIMUM [$F_Q^T \cdot P_{Rel}$] VERSUS AXIAL CORE HEIGHT

DURING NORMAL OPERATION +6, -9% ΔI BAND



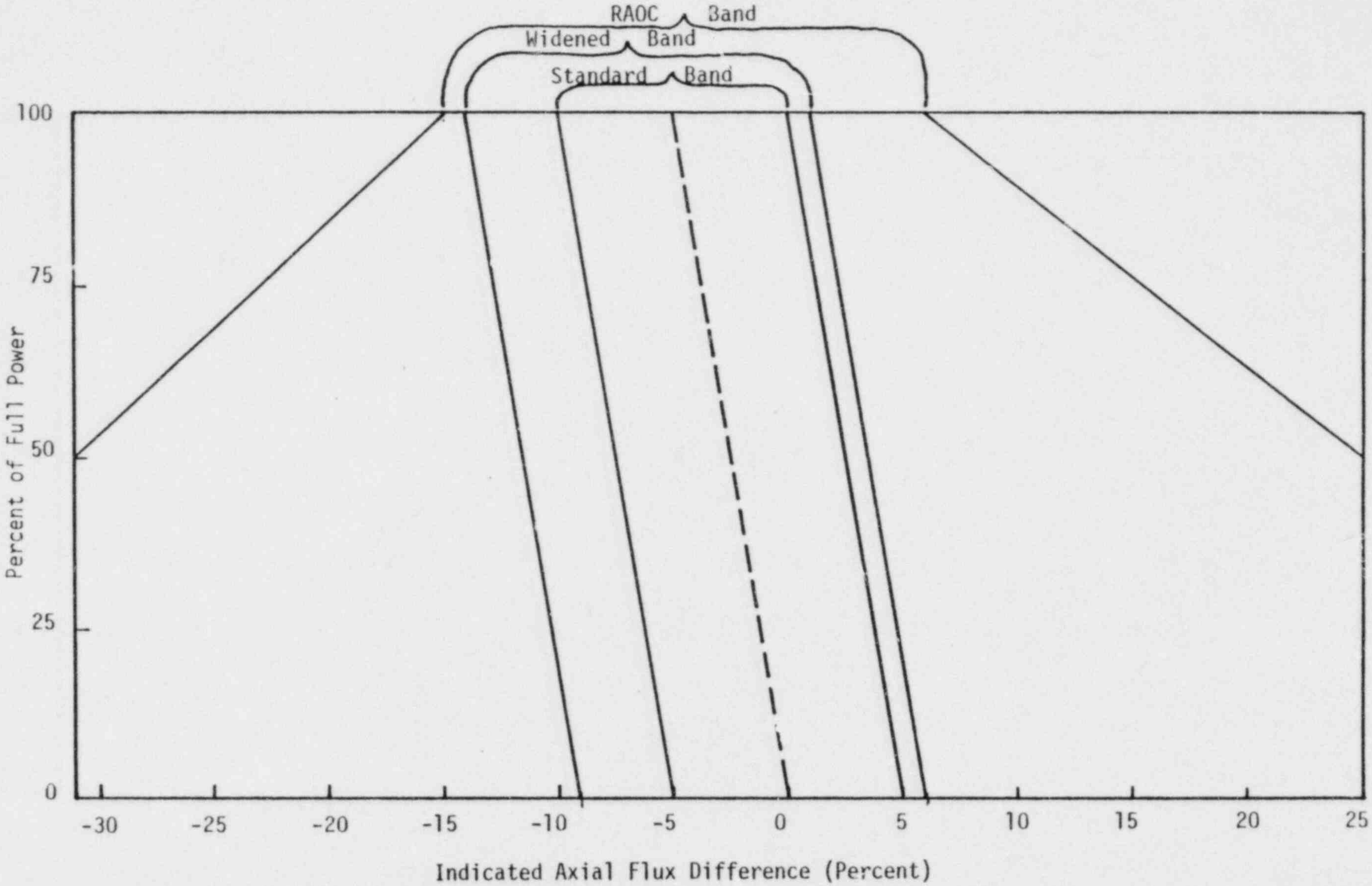


FIGURE I-5

EXAMPLE OF BANDWIDENING POSSIBLE WITH RAOC

II. CALCULATIONAL PROCEDURE

A. XENON RECONSTRUCTION

In the normal CAOC 18 case analysis, load follow simulations, which generate power distributions covering the allowed CAOC operating space, are performed to generate a typical range of allowed axial xenon distributions which in turn are used to calculate axial power distributions in both normal operation and Condition II accident conditions. Because of the much larger allowed operating space during RAOC operation, load follow simulations are not a practical method for generating power distributions covering this wider ΔI-Power operating space. Therefore, for RAOC analyses, axial xenon distributions are created by a reconstruction model. This reconstruction model creates an axial xenon distribution by a five term Fourier series expansion: +(a,c)

$$Xe(z) = \sum_{n=1}^{5} A_n \sin\left(\frac{n\pi z}{L + 2\delta}\right)$$

where: Xe(z) = the xenon concentration at axial position z

z = axial height

L = core height

δ = extrapolation distance

A_n = Fourier coefficients

Five parameters of the xenon distribution are preserved. The coefficients, A_n, can be derived from these parameters by appropriate matrix inversion.

The following parameters are useful in understanding the reconstruction model.

+(a,c)

a) Average, $\bar{X}e = \frac{1}{L} \int_{0}^{L} Xe(z)dz$

b) Skewness, $\Delta Xe = \frac{1}{L}\left(\int_{L/2}^{L} Xe(z)dz - \int_{0}^{L/2} Xe(z)dz \right)$

c) Top Third, XETOP $= \frac{3}{L}\left(\int_{\frac{2L}{3}}^{L} Xe(z)dz \right) - \bar{X}e$

d) Middle Third, XEMID $= \frac{3}{L}\left(\int_{\frac{L}{3}}^{\frac{2L}{3}} Xe(z)dz \right) - \bar{X}e$

e) Bottom Third, XEBOT $= \frac{3}{L}\left(\int_{0}^{L/3} Xe(z)dz \right) - \bar{X}e$

f) Middle Two-Thirds, XE2/3AVG $= \frac{3}{2L}\left(\int_{\frac{L}{6}}^{\frac{5L}{6}} Xe(z)dz \right) - \bar{X}e$

These parameters are typically expressed in units of 10^{-9} Xenon atoms/b-cm. The five parameters preserved by the xenon reconstruction model are then

a) Average, $\bar{X}e$

b) Skewness, ΔXe

c) Middle Third, XEMID

d) Top Third - Bottom Third, XETOP-XEBOT

e) Middle Two-Thirds, XE2/3AVG

Empirically, it has been determined that two of the distribution parameters can be related to the remaining three through correlations, namely

[XETOP-XEBOT = f ($\bar{X}e$, ΔXe)

XE2/3AVG = g ($\bar{X}e$,XEMID)

Thus, there are only three parameters necessary to define an axial xenon distribution.] +(a,c)

The accuracy of the reconstruction model has been verified by two methods. They are:

a) Comparison of reconstructed Xe(z) values with those of the diffusion theory created distributions having the same xenon parameters,

b) Comparison of axial offset and F_z differences obtained with the actual and reconstructed xenon models.

Figure II-1 shows a typical envelope of pointwise Xe(z) differences. These differences over most of the core are [<5%.] Near the top and bottom of the core differences are larger, but do not impact RAOC limit analysis. Figure II-2 shows histograms of A.O. and F_z differences. In general, AO's agree within [0.5%] and F_z's agree within [1%.] Because of the wide range of xenon distributions examined in the RAOC analysis, the accuracy of the reconstruction model to reproduce any individual xenon distribution, and its associated power distributions, is not important. The accuracy in AO and F_z is quite sufficient for the enveloping studies for which the reconstruction model is used. +(a,c) +(a,c)

B. XENON LIBRARY

The xenon reconstruction model makes it possible to accurately recreate an axial xenon distribution from the xenon parameters. Therefore, pointwise xenon distributions need not be stored since they can be recreated from their characteristic parameters. In addition, the reconstruction model eliminates the need to simulate a large number of xenon transients to generate the allowed range of xenon distribution. Instead, a few selected xenon transients can be analyzed to determine the allowed range of xenon parameters. These parameters then constitute the xenon parameter library. The remainder of this section describes the generation of the xenon library.

[Although important in terms of global reactivity, and therefore critical boron concentration, $\bar{X}e$ is relatively unimportant in terms of xenon shape and, hence, power distribution analysis. Of primary importance to the xenon library are the xenon parameters ΔXe and XEMID since these parameters determine the shape of the axial xenon distribution.] +(a,c)

The first step in determining the range of the xenon parameters is to select a tentative ΔI-Power operating space. The tentative operating space should be at least as wide or wider than the expected LOCA/LOFA limits. This will insure that the xenon parameter ranges are conservative. However, the tentative space should not be so large as to result in overly conservative parameter ranges. A poor selection will result in a time consuming iterative process to arrive at the final allowed operating space. A reasonable initial operating space is the widest space allowed at any time during the cycle by the administrative runback line and CAOC operation. This is illustrated in Figure II-3.

Xenon transient calculations are executed with ΔI maintained within the tentative ΔI-Power space. The sequence of these calculations is as follows:

[+(a,c)

a) Set the reactor power at P1 (input)

b) Adjust the ΔI to the most positive value allowed within the tenative limits by changing control rod insertion

c) Obtain the equilibrium xenon distribution

d) Change reactor power to P2 (input)
]

+(a,c)

e) Adjust the ΔI to most negative value by changing control rod insertion

f) Deplete xenon every one hour for up to 40 hours and calculate xenon parameters

g) Maintain the ΔI at the most negative value during this time

h) If ΔI control cannot be maintained the calculation is terminated at the exact time the violation starts.

i) Repeat steps a-h going from the most negative ΔI to the most positive ΔI

j) Repeat steps a-i for various combinations of P1 and P2

k) Plot ΔXe vs. XEMID, determine range of $\bar{X}e$

l) Repeat steps a-k for various burnups (BOL, MOL, EOL)

In all the above steps the control rods must meet rod insertion limit constraints.

The recommended burnup steps and power levels are listed in Table II-1. A typical plot of ΔXe vs. XEMID (Step k) is shown in Figure II-4. This result indicates the allowed ΔXe and XEMID range for that burnup step.

The results of the above transient calculations for a typical Westinghouse reload core are shown in Figures II-5, II-6, and II-7 at BOL, MOL, and EOL respectively.

TABLE II-1

+(a,c)

Burnups	Powers (P1-P2)
BOL	100-70
	70-100
MOL	
	100-50
EOL	50-100
	100-30
	30-100

All combinations of power and burnup are calculated, resulting in 18 total cases.

+(a,c)

The allowed ΔXe-XEMID space, as shown in Figure II-4, at each of three burnups (BOL, MOL, EOL) then becomes the xenon library. In addition, from the range of $\bar{X}e$ determined from the transient cases, three $\bar{X}e$ are selected for inclusion in the library. These three are:

a) the highest value,

b) the lowest value,

c) the average value.

The $\bar{X}e$'s for a typical Westinghouse reload core are 3.25, 1.5, and 2.5.

C. NORMAL OPERATION ANALYSIS

1. POWER SHAPE GENERATION

In the standard CAOC analysis the generation of normal operation power distributions is constrained by the rod insertion limits (RIL) and ΔI band limits. The purpose of RAOC is to find the widest permissible ΔI-Power operating space by analyzing a wide range of ΔI. Therefore the generation of normal operation power distributions is constrained only by the RIL. The sequence for generating the power distributions is then:

+(a,c)

a) Select a power level

b) Select a set of xenon distribution parameters; ie, one of the points in the ΔXe-XEMID allowed space and a $\bar{X}e$

c) Reconstruct the xenon distribution

d) With the xenon distribution fixed, step the rods from ARO to the RIL. Maintain criticality by soluble boron concentration adjustment.

+(a,c)

e) Store P(z), power level, ΔI, and rod position for each rod position in d)

f) Repeat Steps b-e until the allowed xenon parameter space is covered

g) Repeat Steps a-f for a range of power levels (a minimum of three power levels, 100%, 50% and an intermediate power, are required)

h) Repeat Steps a-g for various burnups (BOL, MOL, EOL)

The results of the above process is a large set of power distributions covering a large area of ΔI-Power space. A brief representation of this space is shown in Figure II-8. This data is used as input to the LOCA and LOFA analysis.

2. F_Q ANALYSIS

Each power shape generated in Section C.1, above, is analyzed to determine if LOCA constraints are met or exceeded. The total peaking factor, F_Q^T, is determined using standard synthesis methods as described in WCAP-8385. For each power level, the results of this analysis will indicate a range of ΔI in which there are no violations of the LOCA limits. This range is plotted for all the power levels analyzed and a bounding limit is determined. This is illustrated in Figure II-9. This bounding limit becomes the tentative allowed ΔI-power operating space for the plant, pending the results of the Loss of Flow Accident (LOFA) and Condition II Accident Analyses.

The LOCA limited ΔI-Power operations space for a typical Westinghouse reload core is shown in Figure II-10.

3. LOFA Analysis

The thermal-hydraulic methods used to analyze axial power distributions generated by the RAOC methodology is similar to those used in the CAOC methodology. Normal operation power distributions are evaluated relative to the assumed limiting normal operation power distribution, typically the 1.55 cosine, used in the accident analysis. Limits on allowable operating axial flux imbalance as a function of power level from these considerations are compared to those resulting from LOCA F_Q considerations, (Figure II-10), and the most restrictive limits determined.

D. CONDITION II ANALYSIS

The objectives of Condition II simulation (Accident Simulation) are to:

(a) Evaluate whether the consequence of the specified accident satisfy the design basis of safety related items, i.e., the maximum power density and design basis axial power shape used in DNBR evaluations.

(b) Provide, if necessary, information to obtain appropriate setpoints for core protection systems which assure the validity of the design basis. This will be accomplished by such means as redefining the f(ΔI) penalty function in the Overtemperature ΔT setpoint equation (OTΔT).

Pre-accident conditions have to satisfy the normal operating conditions, i.e.:

(a) Control rods are above their insertion limit.

(b) The flux difference, ΔI, has to be within the ΔI-Power space determined in the Normal Operation Analysis.

Axial xenon distributions are generated by the xenon reconstruction model for the range of ΔXe, XEMID and XEAVG's allowed during normal operation (ie, within the ΔI-Power Operating space determined in the normal analysis). Starting from a normal operating condition, the following accidents are simulated.

Cooldown Accident (Manual Rod Control Mode)

This accident assumes reduction of the inlet temperature of the primary coolant due to a sudden excessive load increase, steam dump valve opening, excessive feed water flow or a turbine valve opening. The control rods are assumed to stay at their original insertion. The reactor power increases as a result of this accident. The maximum amount of temperature reduction is limited to 30^{O}F. The cooldown will be terminated if the reactor power reaches the high flux trip point even if the amount of temperature reduction is less than 30^{O}F.

Control Rod Withdrawal

This accident assumes uncontrolled full length control rod withdrawal either by system malfunction or operator error. The boron concentration is fixed. The control rod is withdrawn every 10% of core height up to the fully withdrawn position. A reactor trip occurs if the reactor power reaches the high flux trip point. This analysis also simulates excessive (uncontrolled) load increase with automatic control rod operation.

Boration/Dilution (Automatic Rod Control Mode)

An uncontrolled boration/dilution accident is the result of a system malfunction or operator error, and is simulated as follows. The reactor power is maintained at a constant level. The reactivity change associated with the boration/dilution is compensated by automatic control rod motion. The boration is terminated when all rods are out of the core. The dilution is terminated 15 minutes after the rods pass the rod insertion limits.

1) Power Shape Generation

The first step in the Condition II analysis is the determination of the allowable normal operation preconditions. This is accomplished by selecting a set of xenon distribution parameters and searching for the control rod insertions at a given power (constrained by the rod insertion limits) that are permissible within the ΔI-Power operating space determined in the normal operation analysis. This is illustrated in Figure II-11. For that xenon distribution and power level, any rod insertion between these limits is a valid normal operation precondition for the accident analysis. The process for the accident analysis is then

+(a,c)

a) Select a set of xenon distribution parameters from the xenon distribution library and reconstruct the xenon distribution,

b) Select a power level,

c) Search for the deepest and shallowest rod insertion allowed by the ΔI-Power operating space.

d) Originate accidents from rod positions between the limits determined in c).

e) Store P(z), power level, ΔI, and rod position at each step of the accident simulation,

f) Repeat steps b-e for power levels $0.5 \leq P \leq 1.0$,

g) Repeat steps a-f until the range of xenon parameters is spanned.

The power distributions generated in this sequence are then analyzed for peak power density (Kw/ft) and DNB concerns.

2) Peak Power Density

Core peaking factors can be obtained by the standard synthesis procedures using 1-D calculated axial power shapes and power levels obtained from the accident simulations and input F_{xy}'s. The results are summarized in flyspeck format as shown in Figure II-12. Usually peak power density will exceed the design basis limit only in very large axial offset (or ΔI) regions. These regions are easily protected by operator action and/or an operationally non-restrictive OPΔT f(ΔI) penalty function. (Current 17x17 plants with CAOC control operate based on an analysis without an OPΔT f(ΔI) penalty function since the OTΔT f(ΔI) penalty function is more restrictive. If the need for an OPΔT f(ΔI) penalty function is indicated by the RAOC analysis, the OTΔT f(ΔI) function would be changed such that it would be more restrictive.)

3) DNB and Setpoint Analysis

The Condition II analyses are evaluated relative to the axial power distribution assumptions used to generate DNB core limits and resultant OTΔT setpoints (including the f(ΔI) function) to determine if the setpoints are adequate for the RAOC generated conditions.

E. FINAL DETERMINATION OF RAOC LIMIT

Once the normal operation and accident analysis described in the previous sections has been completed, the final determination of the RAOC allowed ΔI-Power operating space can be made. This is accomplished by first comparing the LOCA allowed ΔI-Power operating space to that of the LOFA and selecting the most limiting operating space allowed by these normal operation limited accidents. This result is then compared to the trip setpoints that result from the OPΔT and OTΔT f(ΔI) penalty functions to insure that the trip setpoints are non-restrictive.

The resulting ΔI-Power space from this determination for a typical Westinghouse reload core is shown in Figure II-13.

F. SENSITIVITY STUDIES FOR VARIOUS F_Q LIMITS

The sensitivity of ΔI-Power operations space to changes in F_Q were analyzed through a wide range of F_Q's. The method of analysis is identical to the F_Q analysis described in Section C.2, with F_Q varied for each sensitivity case. The results indicate that a 1% change in F_Q will cause less than a 1% change in ΔI. As ΔI is under the control of the operator, F_Q can be conservatively reduced by a 1% reduction in ΔI for each 1% F_Q is to be decreased.

This conservative relationship of 1% ΔI per 1% F_Q is used in the Technical Specifications incorporating F_Q Surveillance to reduce the allowed ΔI-Power operating space in the event a measured F_Q indicates insufficient margin to the F_Q limit to allow use of the full ΔI-Power operating space.

G. IMPACT ON REMAINING SAFETY ANALYSIS

The impact of the wider ΔI-Power space allowed by RAOC on safety parameters other than those discussed in the previous section has been evaluated. No change in the methods of determining these safety parameters is required as a result of RAOC for the following reasons.

a) The current methodology as described in WCAP-9272, "Westinghouse Reload Safety Evaluation Methodology," is sufficiently conservative to bound RAOC operation. This is a result of the conservative methods used to bound the power distiribution skewing allowed by CAOC.

b) Although the allowed ΔI-Power operating space is larger for RAOC than it is for CAOC, the plant is physically able to operate at the extremes of the allowed space for only brief periods of time. The plant will always tend toward the equilibrium value of ΔI, i.e. the CAOC target value, as any xenon oscillation decays. As a result the most probable power distribution occuring during normal operation of the plant will be within the CAOC ΔI-Power allowed operations space.

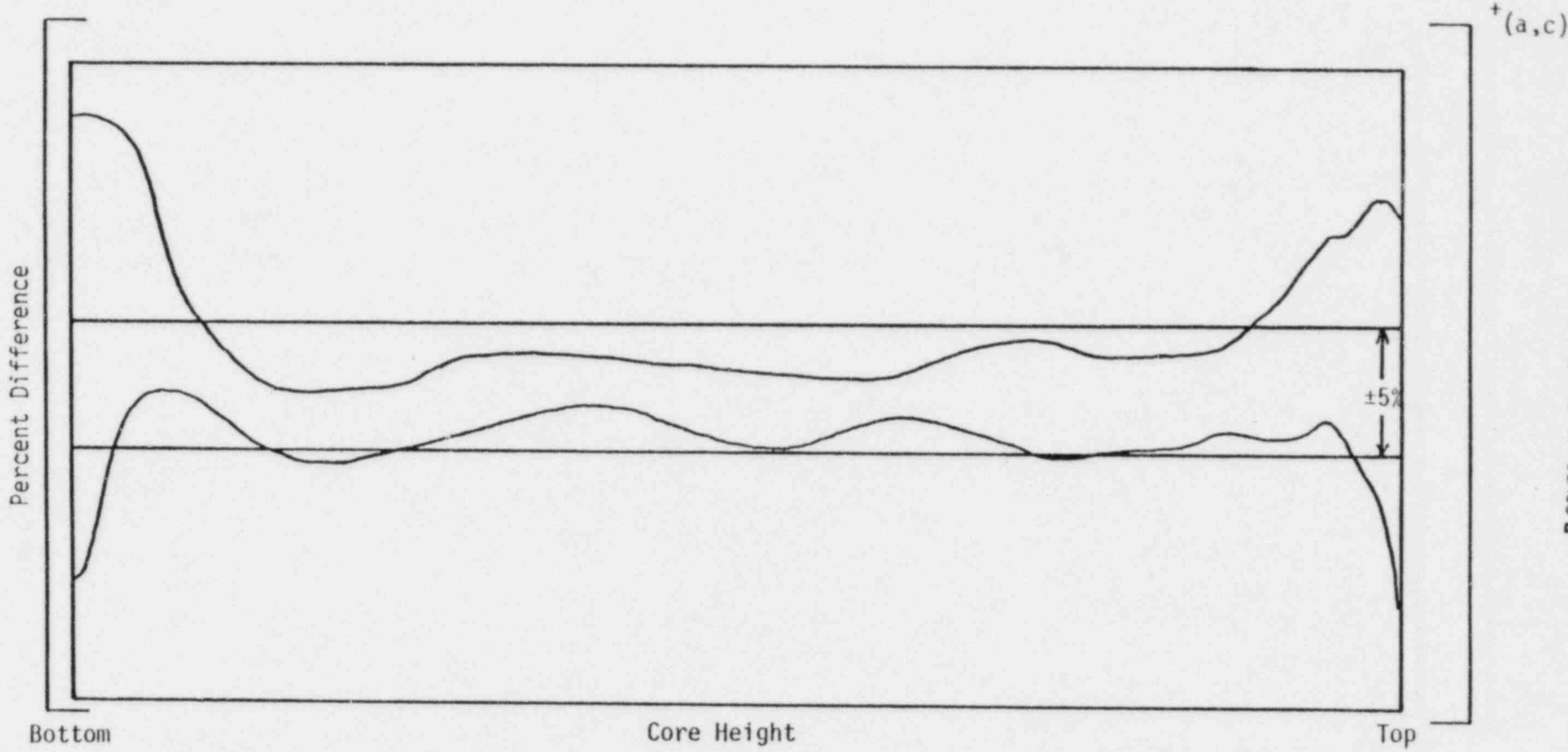
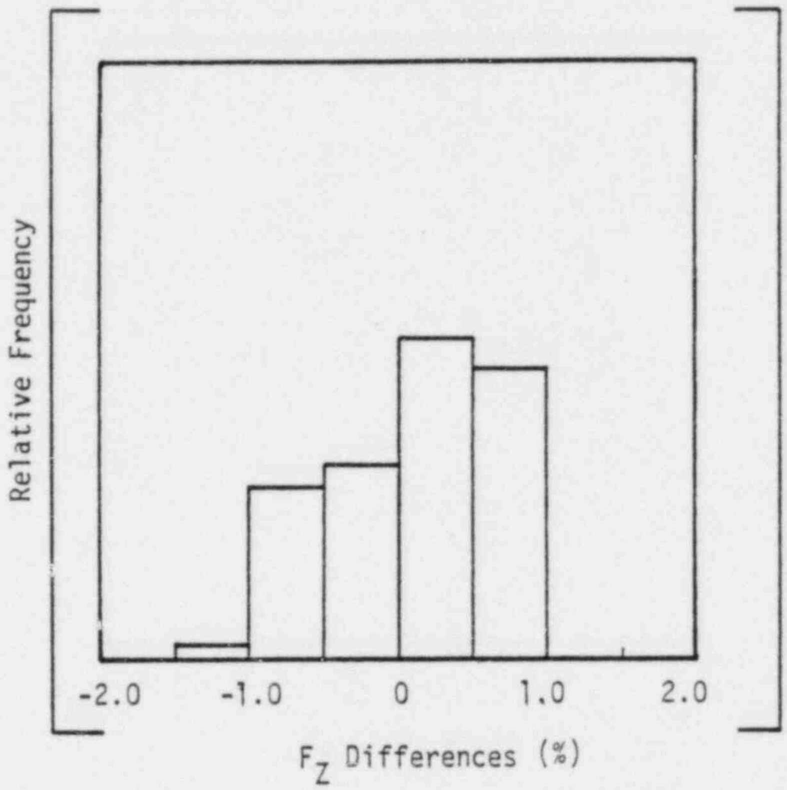


FIGURE II-1

XENON RECONSTRUCTION MODEL ENVELOPE OF LOCAL XENON CONCENTRATION DIFFERENCES

+(a,c)



+(a,c)

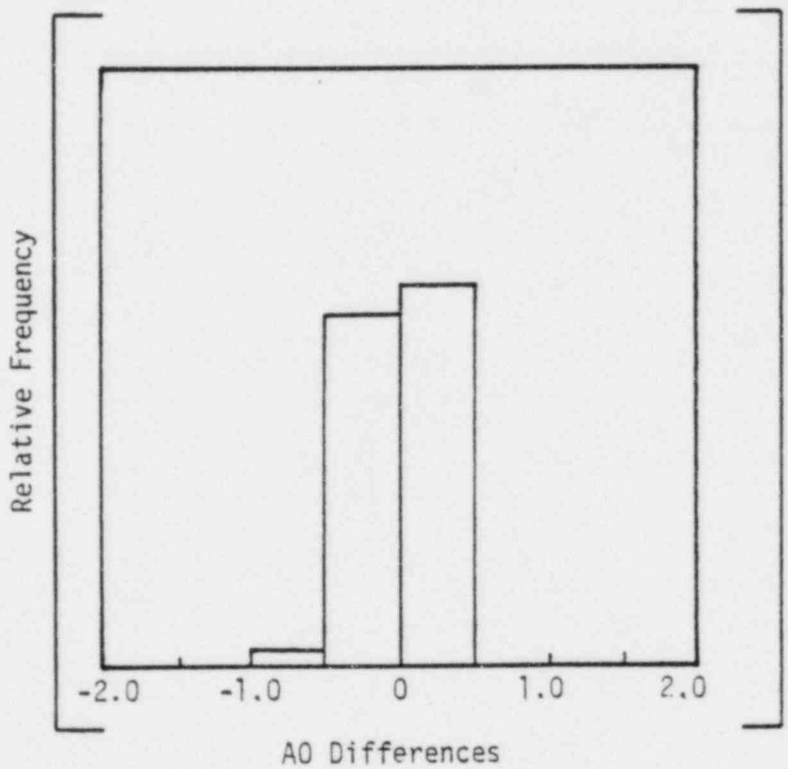


FIGURE II-2

XENON RECONSTRUCTION MODEL

HISTOGRAMS OF F_Z AND AO DIFFERENCES

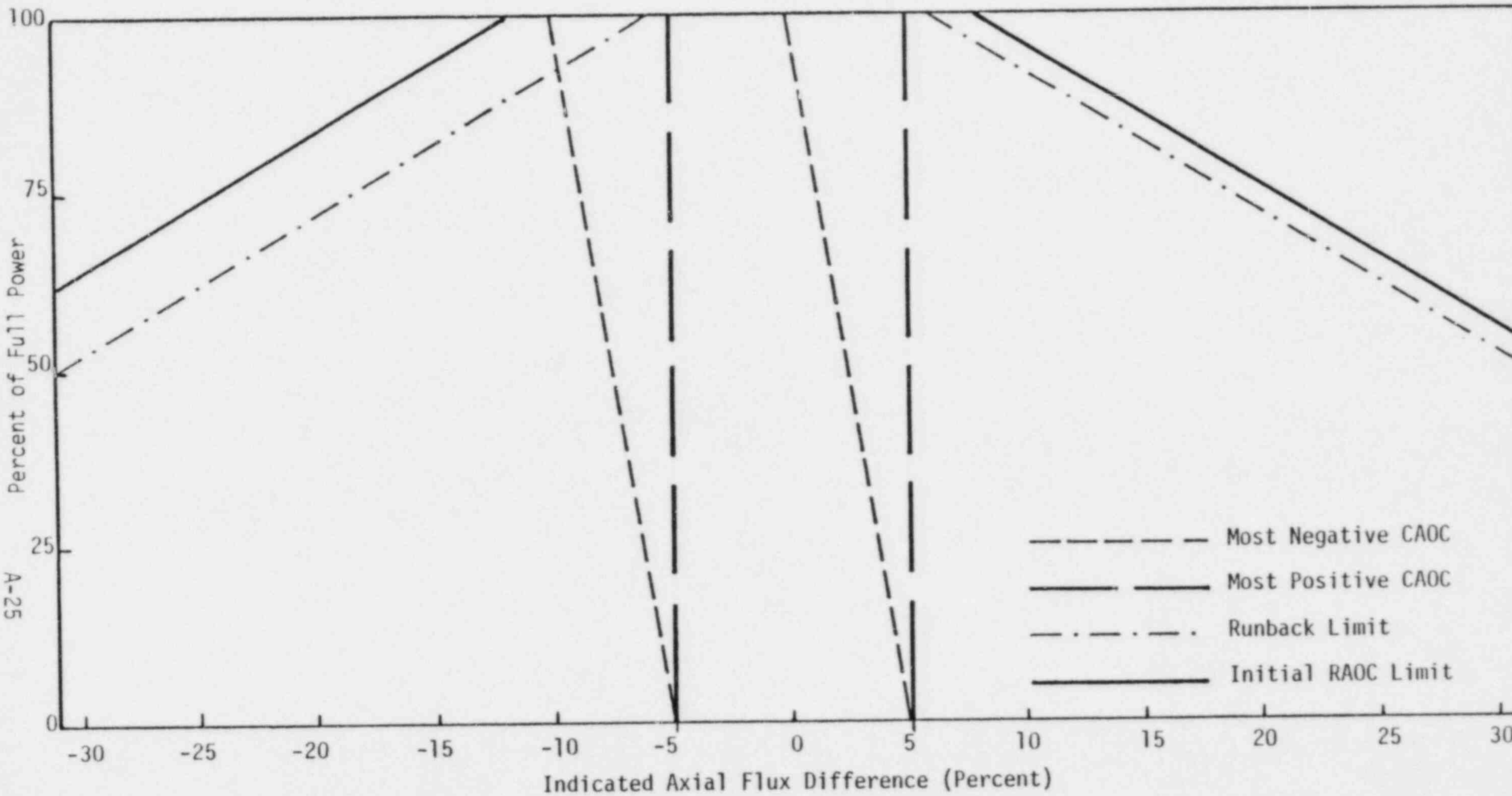


FIGURE II-3

EXAMPLE OF SELECTING PRELIMINARY RAOC LIMITS

+(a,c)

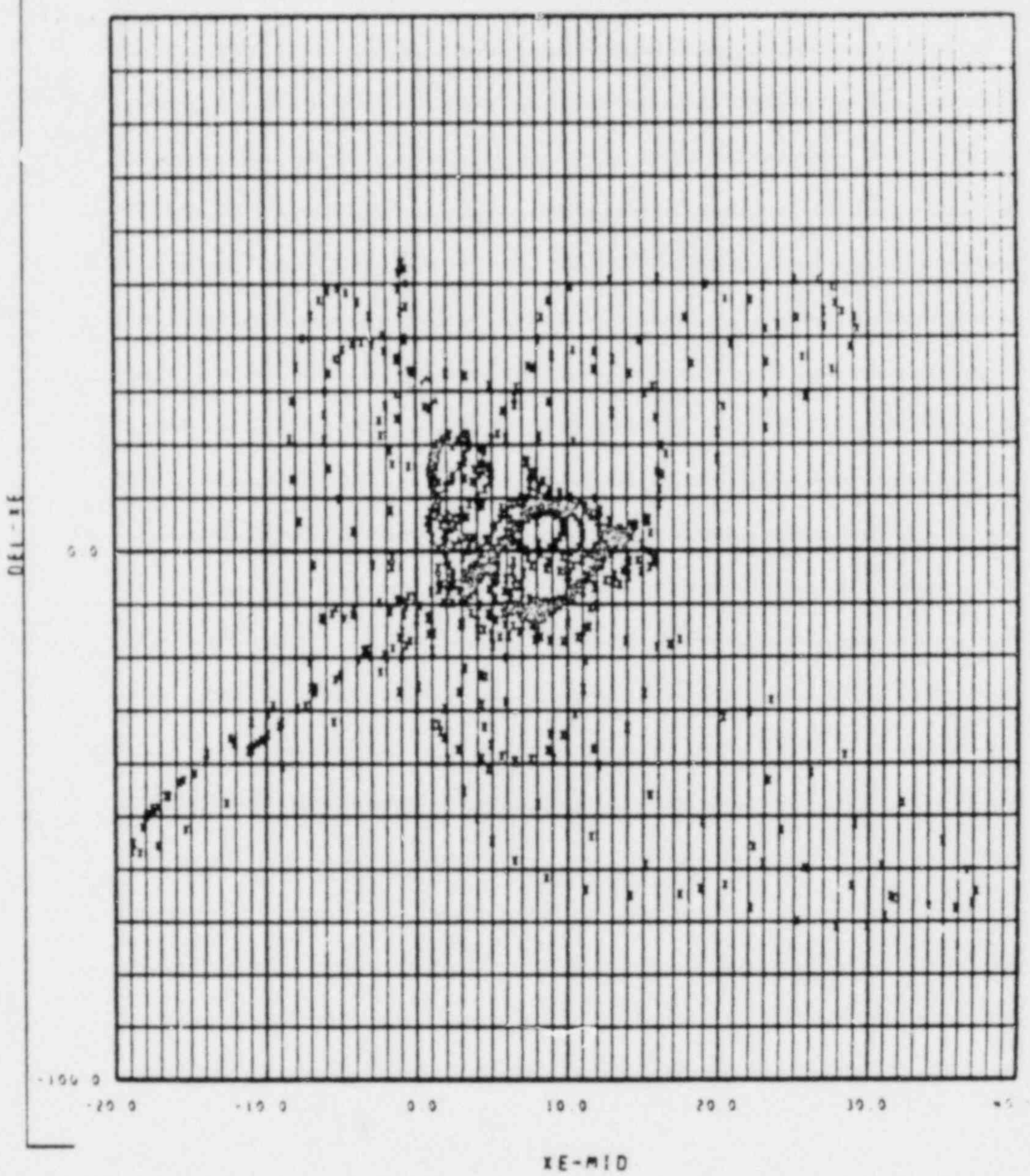


FIGURE II-4

SAMPLE PLOT OF XENON PARAMETERS FROM TRANSIENT CALCULATION

+(a,c)

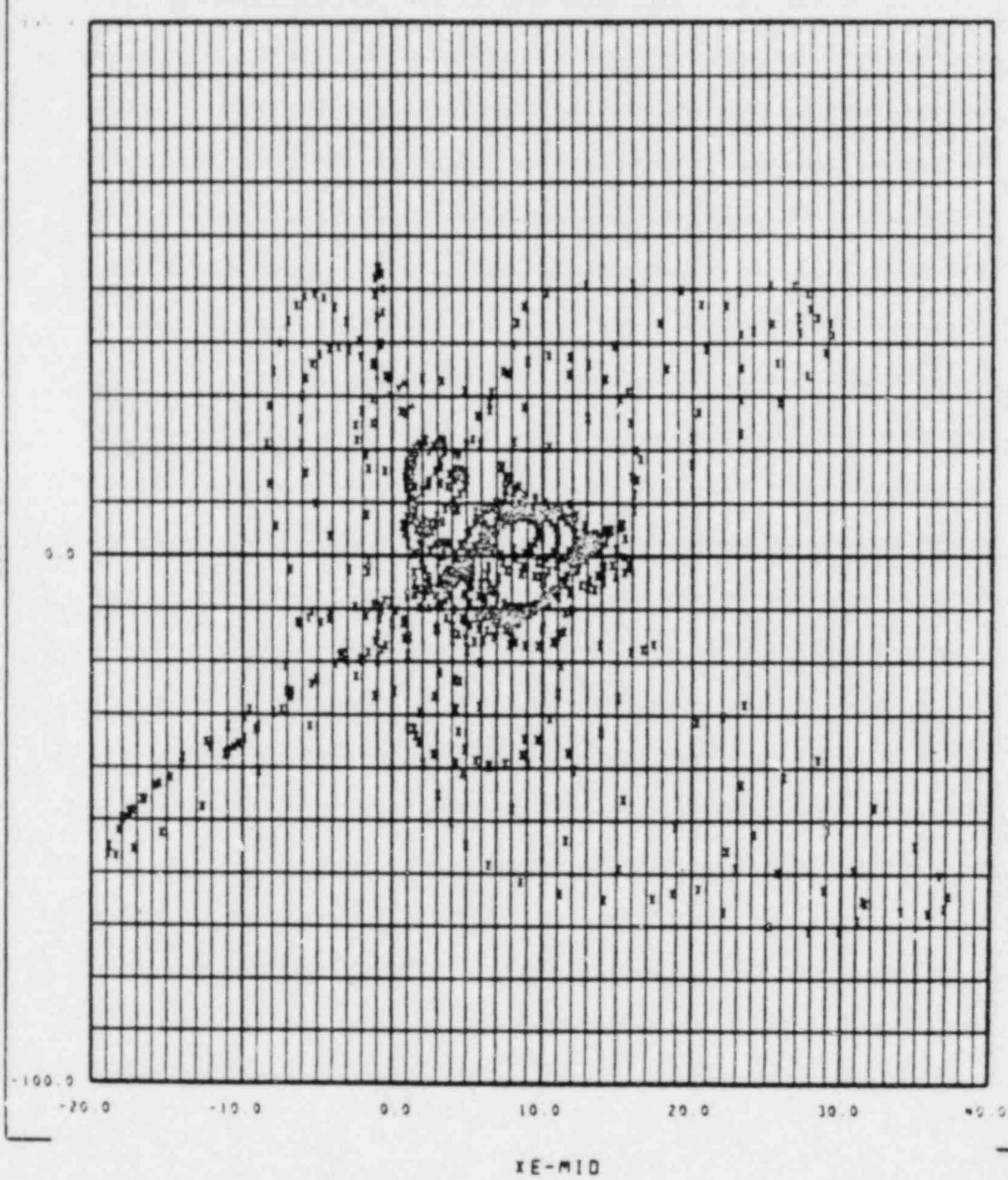


FIGURE II-5

TYPICAL WESTINGHOUSE RELOAD CORE

RESULTS OF XENON TRANSIENTS AT BOL

+(a,c)

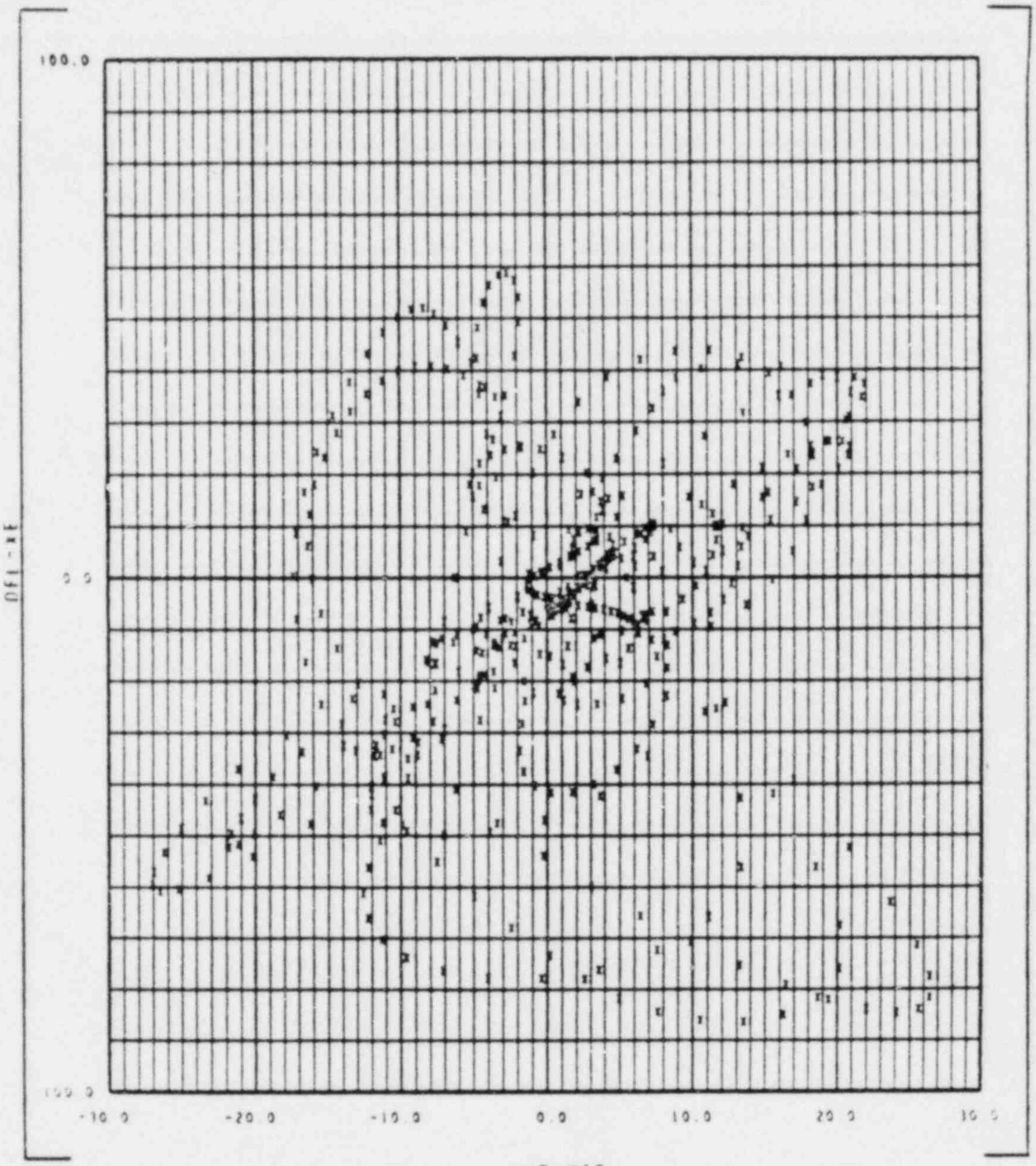


FIGURE II-6

TYPICAL WESTINGHOUSE RELOAD CORE

RESULTS OF XENON TRANSIENTS AT MOL

+(a,c)

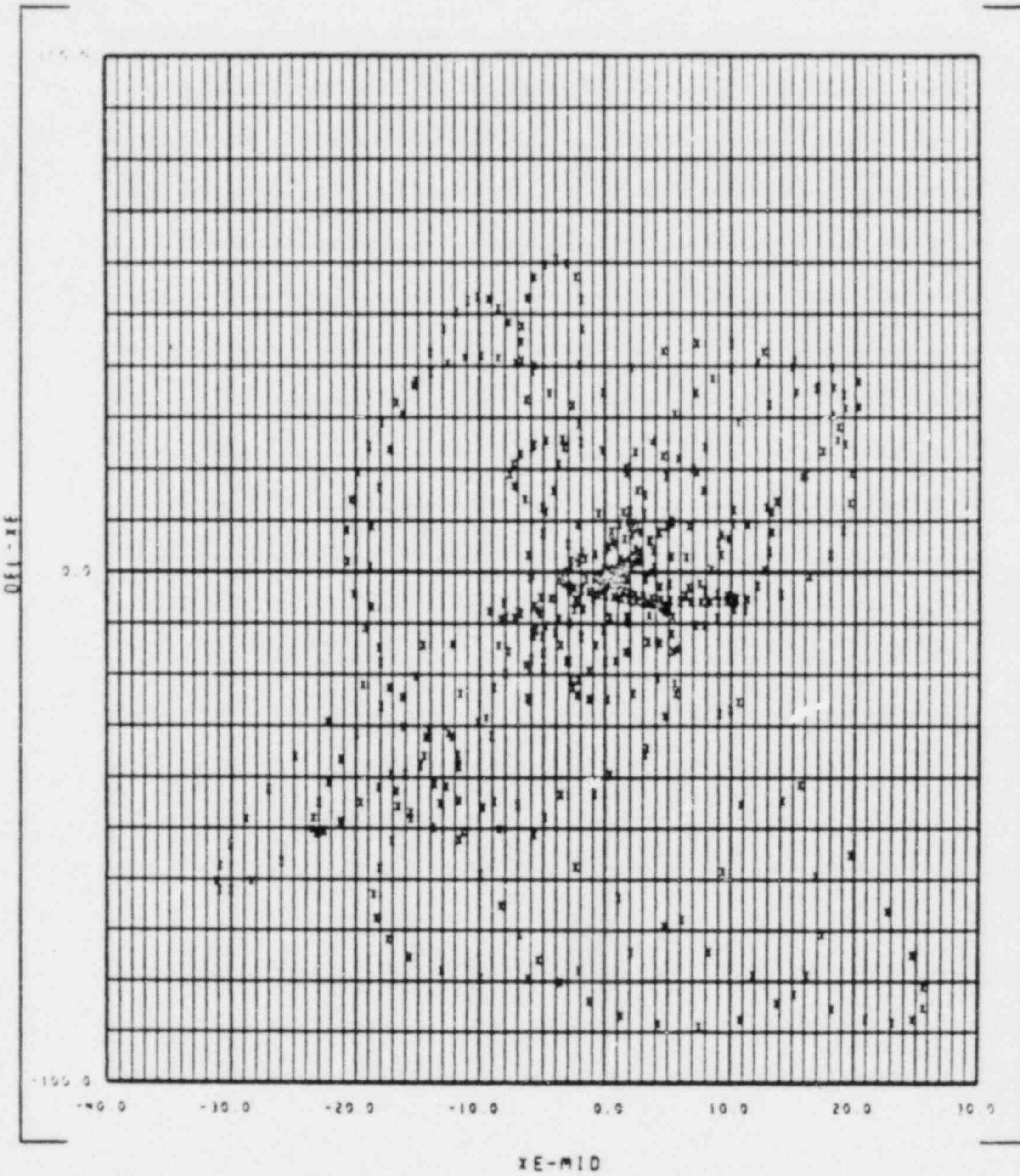


FIGURE II-7

TYPICAL WESTINGHOUSE RELOAD CORE

RESULTS OF XENON TRANSIENTS AT EOL

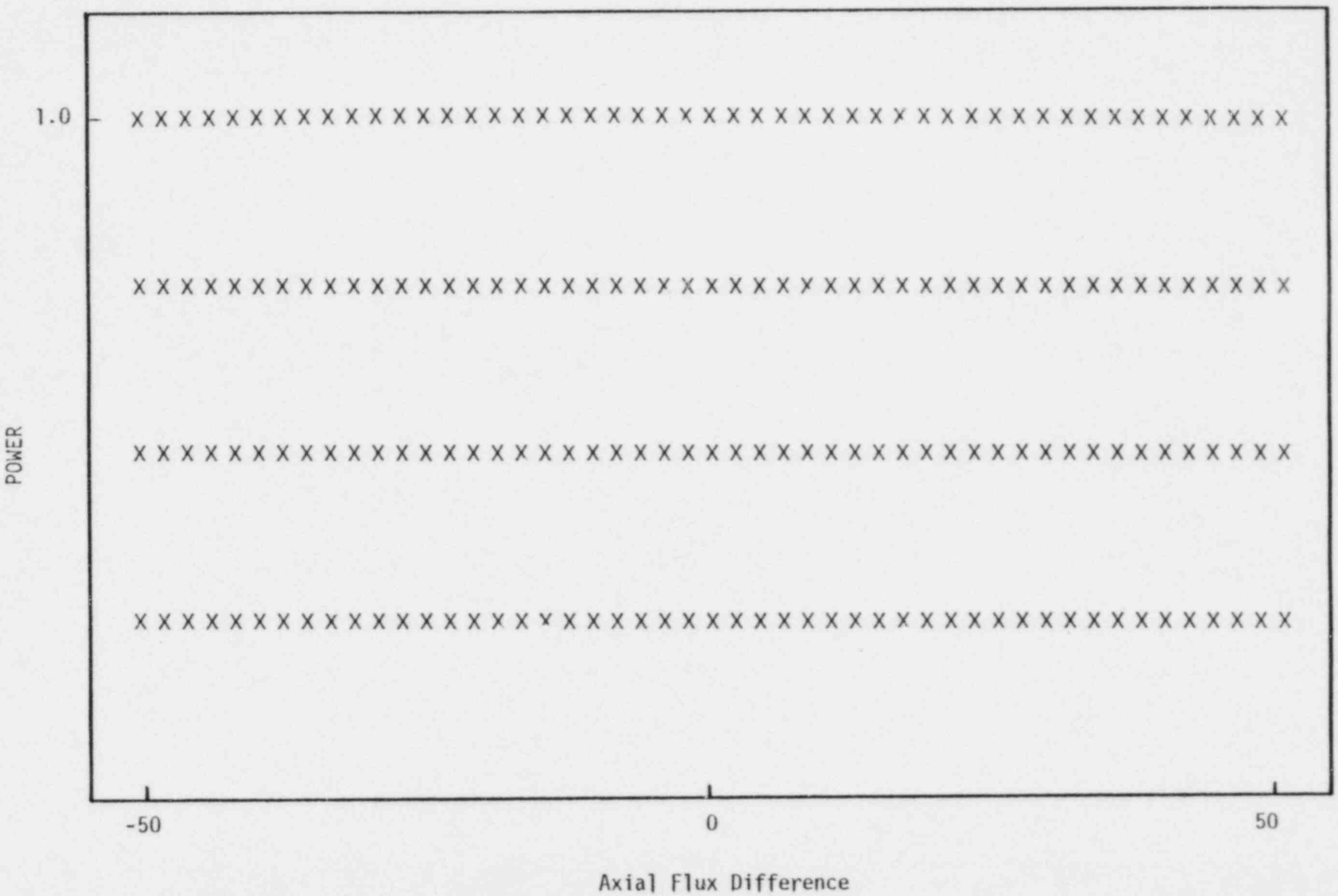


FIGURE II-8

EXAMPLE OF RANGE OF ΔI-POWER SPACE COVERED DURING NORMAL OPERATION ANALYSIS

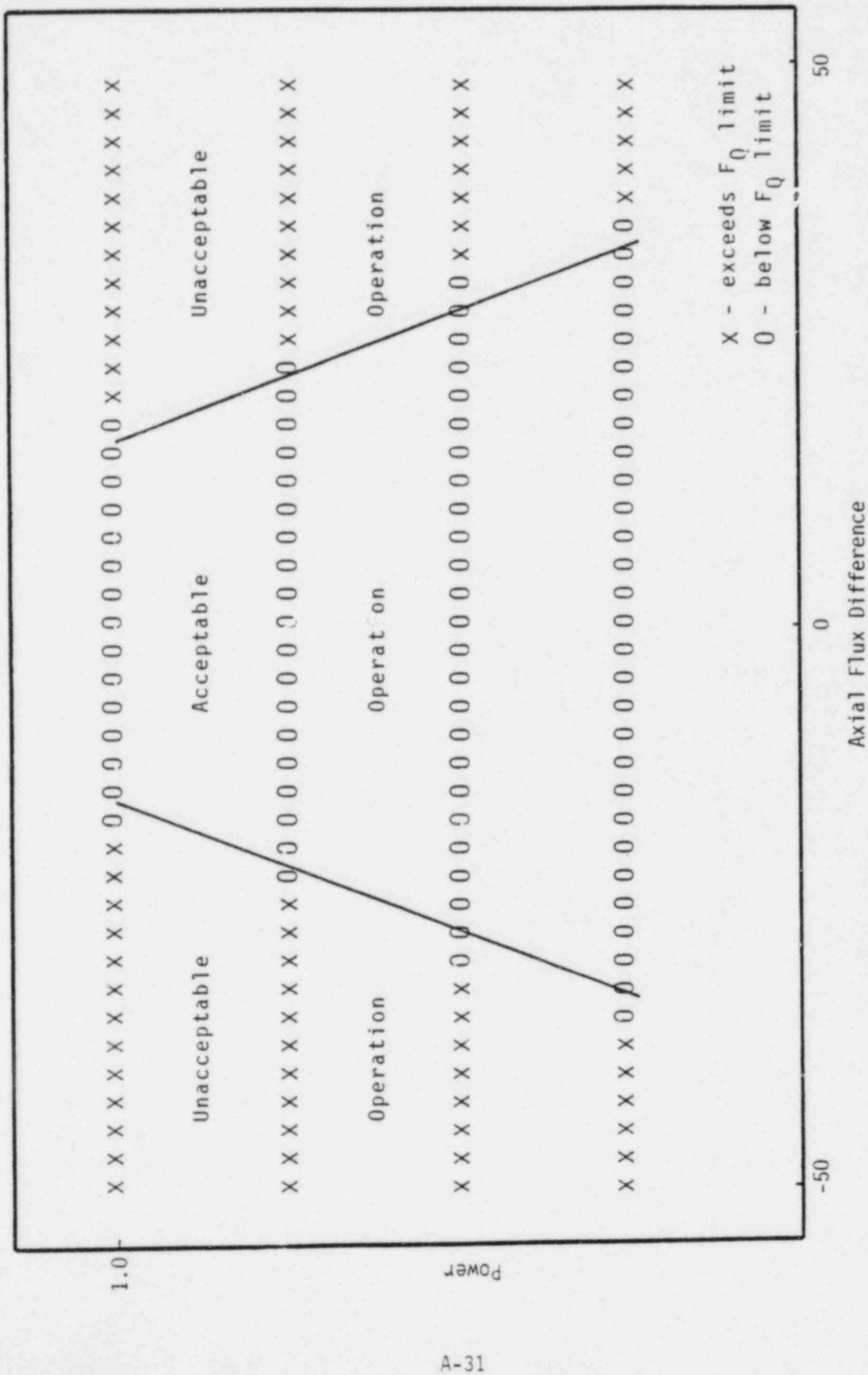


FIGURE II-9

EXAMPLE OF LIMITING ΔI-POWER SPACE BASED ON LOCA CONCERNS

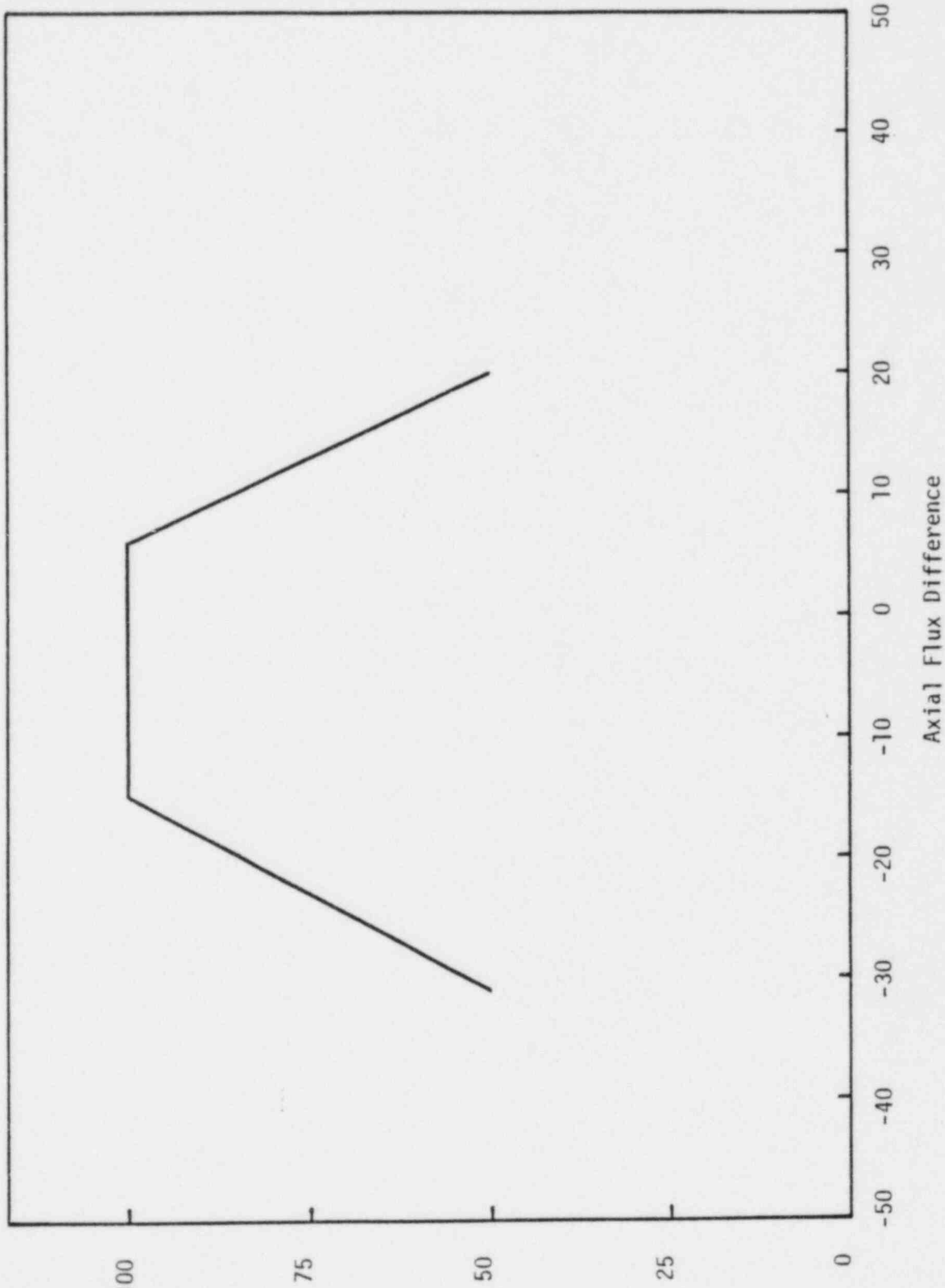


FIGURE II-10

LOCA BASED ΔI-POWER SPACE FOR A TYPICAL WESTINGHOUSE RELOAD CORE

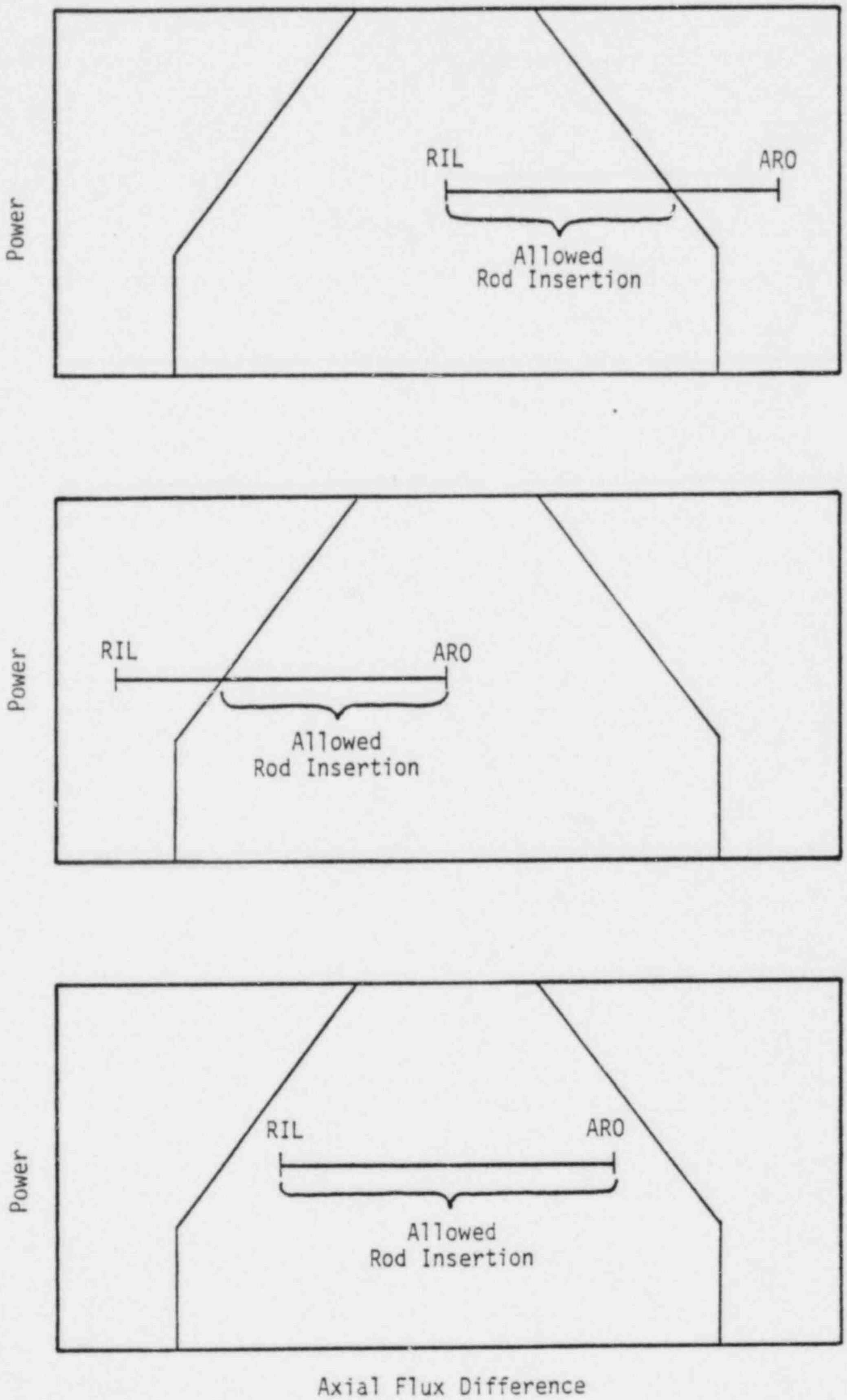


FIGURE II-11

DETERMINATION OF ALLOWED RANGE OF CONTROL ROD INSERTION FOR NORMAL OPERATION

+(a,c)

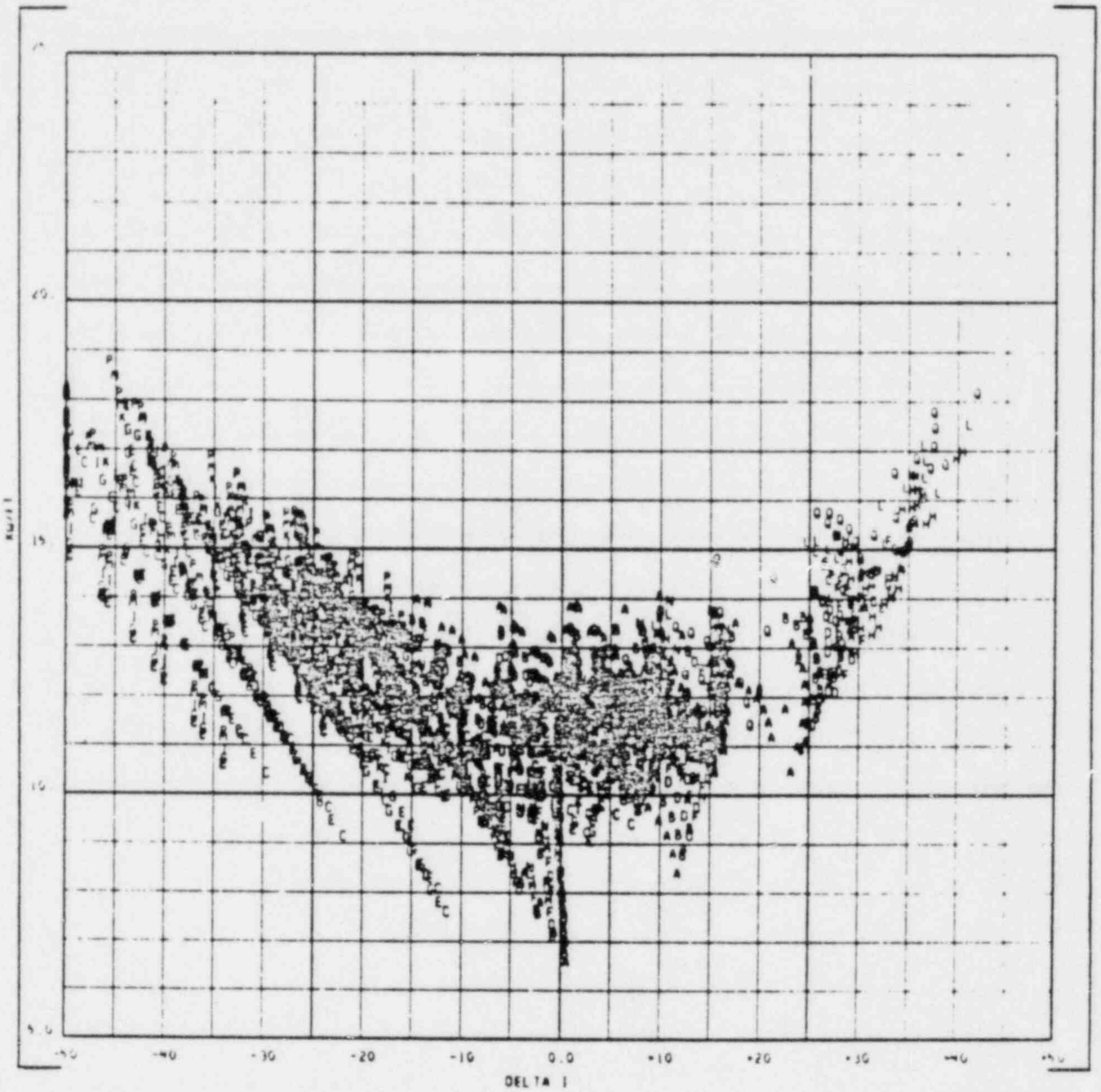
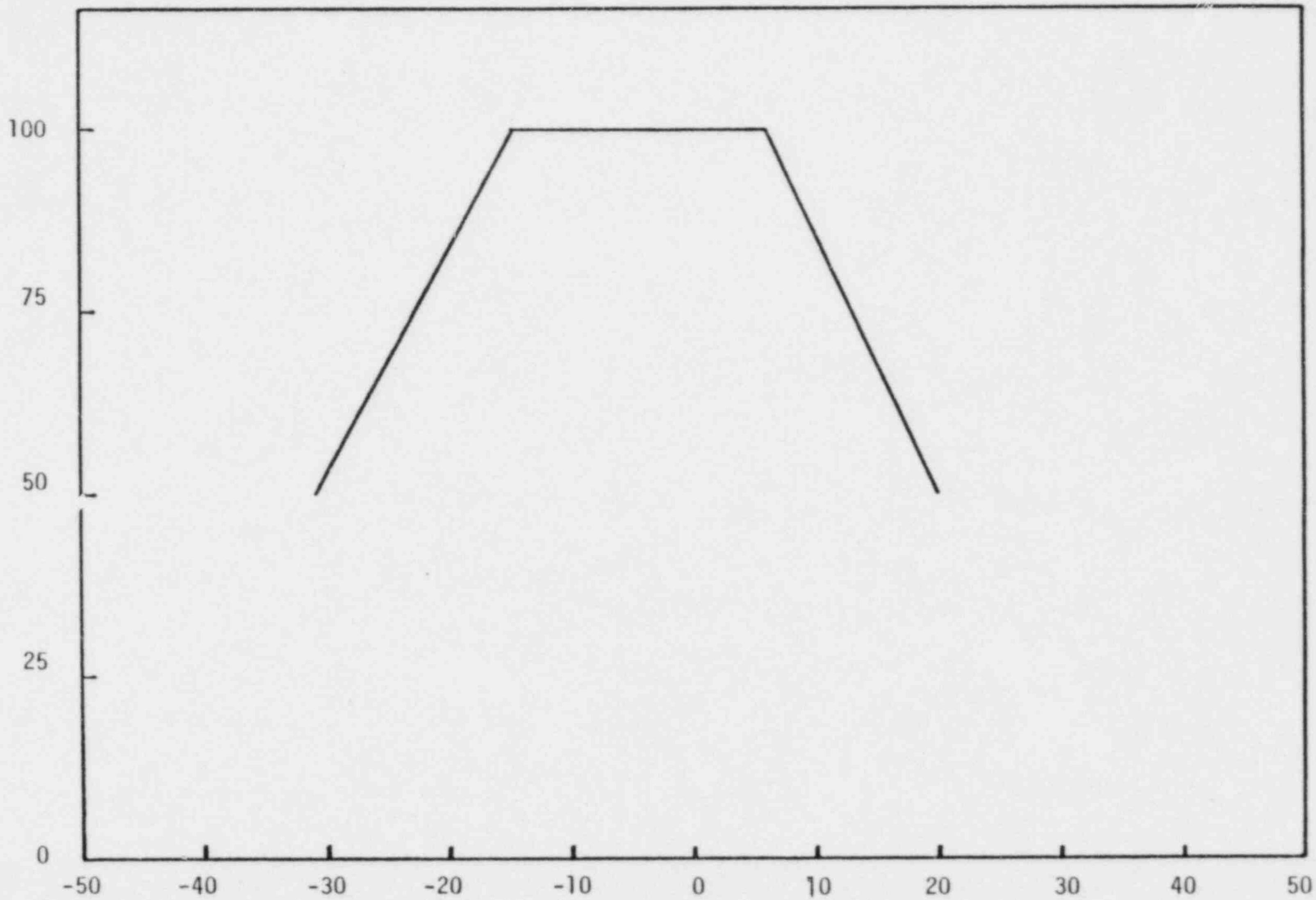


FIGURE II-12

PEAK POWER DENSITY (Kw/ft) DURING
CONDITION II TRANSIENTS
(TYPICAL EXAMPLE)



Axial Flux Difference

FIGURE II-13

FINAL ΔI-POWER OPERATING SPACE FOR A TYPICAL WESTINGHOUSE RELOAD CORE

III. TECHNICAL SPECIFICATIONS

A. MODIFICATIONS TO 3/4.2.1

In a plant incorporating RAOC operation the Technical Specifications are modified to remove all references to CAOC in Section 3/4.2.1 and the corresponding bases. The allowed ΔI-Power operating space determined in the previous section becomes Figure 3.2-1 of the Technical Specification and operation within these limits is required. If these limits are exceeded, ΔI must be returned within the limits within a short grace period or power must be reduced. An example of the modifications to 3/4.2.1 is Section 1 of the attachment. An example of the modifications to the BASES of 3/4.2.1 is Section 2 of the attachment.

B. OTHER POTENTIAL TECHNICAL SPECIFICATION CHANGES

As a result of the OTΔT and OPΔT analysis of the Condition II transients, changes may be required to the f(ΔI) penalty functions in Table 2.2-1 of the Technical Specifications. This may be required on plants with high F_Q limits where wider ΔI limits are possible.

IV. SUMMARY AND CONCLUSIONS

The RAOC methodology has been developed for relaxing the current contraints on axial power distribution control. This methodology widens the allowed ΔI-Power operating space relative to CAOC operation particularly at reduced power levels while ensuring that safety considerations are satisfied. This is achieved by examination of a wide range of possible xenon distributions and the possible range of axial power distributions associated with each xenon distribution in both normal operation and accident conditions. This methodology has been applied to the safety analysis of a typical Westinghouse reload core. With the Technical Specification changes described in this report, the plant can operate both safely and with enhanced flexibility during this cycle.

ATTACHMENT

TECHNICAL SPECIFICATION CHANGES

A.1. MODIFICATIONS TO 3/4.2.1

AXIAL FLUX DIFFERENCE LIMITS

3/4.2 POWER DISTRIBUTION LIMITS

3/4.2.1 AXIAL FLUX DIFFERENCE (AFD)

LIMITING CONDITION FOR OPERATION

3.2.1 The indicated AXIAL FLUX DIFFERENCE (AFD) shall be maintained within the allowed operational space defined by Figure 3.2-1.

APPLICABILITY: MODE 1 ABOVE 50 PERCENT RATED THERMAL POWER

ACTION:

a. With the indicated AXIAL FLUX DIFFERENCE outside of the Figure 3.2-1 limits,

   1.) Either restore the indicated AFD to within the Figure 3.2-1 limits within 15 minutes, or

   2.) Reduce THERMAL POWER to less than 50% of RATED THERMAL POWER within 30 minutes and reduce the Power Range Neutron Flux - High Trip setpoints to less than or equal to 55 percent of RATED THERMAL POWER within the next 4 hours.

b. THERMAL POWER shall not be increased above 50% of RATED THERMAL POWER unless the indicated AFD is within the Figure 3.2-1 limits.

POWER DISTRIBUTION LIMITS

SURVEILLANCE REQUIREMENTS

4.2.1.1 The indicated AXIAL FLUX DIFFERENCE shall be determined to be within its limits during POWER OPERATION above 50 percent of RATED THERMAL POWER by:

a. Monitoring the indicated AFD for each OPERABLE excore channel:

   1. At least once per 7 days when the AFD Monitor Alarm is OPERABLE, and

   2. At least once per hour for the first 24 hours after restoring the AFD Monitor Alarm to OPERABLE status.

b. Monitoring and logging the indicated AXIAL FLUX DIFFERENCE for each OPERABLE excore channel at least once per hour for the first 24 hours and at least once per 30 minutes thereafter, when the AXIAL FLUX DIFFERENCE Monitor Alarm is inoperable. The logged values of the indicated AXIAL FLUX DIFFERENCE shall be assumed to exist during the interval preceding each logging.

4.2.1.2 The indicated AFD shall be considered outside of its limits when at least 2 OPERABLE excore channels are indicating the AFD to be outside the limits.

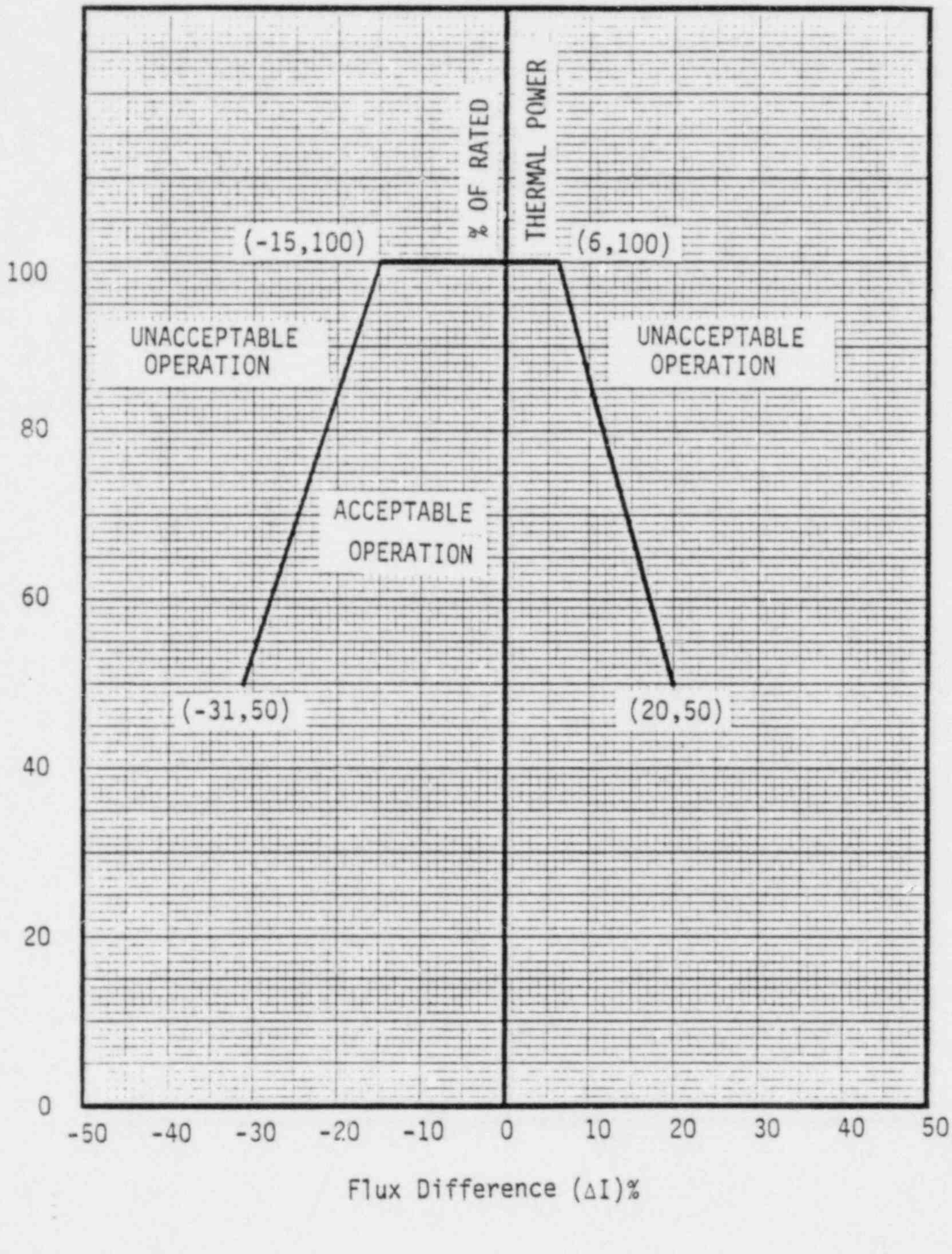


FIGURE 3.2-1

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER
(TYPICAL EXAMPLE)

A.2. MODIFICATIONS TO B 3/4.2.1

BASES FOR AXIAL FLUX DIFFERENCE LIMITS

3/4.2.1 AXIAL FLUX DIFFERENCE (AFD)

The limits on AXIAL FLUX DIFFERENCE assure that the $F_Q(Z)$ upper bound envelope of F_Q^{limit} times the normalized axial peaking factor is not exceeded during either normal operation or in the event of xenon redistribution following power changes.

Provisions for monitoring the AFD on an automatic basis are derived from the plant process computer through the AFD Monitor Alarm. The computer determines the one minute average of each of the OPERABLE excore detector outputs and provides an alarm message immediately if the AFD for at least 2 of 4 or 2 of 3 OPERABLE excore channels are outside the AFD limits and the THERMAL POWER is greater than 50 percent of RATED THERMAL POWER.

THIS FIGURE DELETED

Figure B 3/4 2-1 TYPICAL INDICATED AXIAL FLUX DIFFERENCE VERSUS THERMAL POWER