Applicability

Applies to the limits on core fission power distributions and to the limits on control rod operations.

Objective

To ensure 1) core subcriticality after reactor trip, 2) acceptable core power distribution during power operation in order to maintain fuel integrity in normal operation transients associated with faults of moderate frequency, supplemented by automatic protection and by administrative procedures, and to maintain the design basis initial conditions for limiting faults, and 3) limited potential reactivity insertions caused by hypothetical control rod ejection.

Specification

a. Shutdown Reactivity

When the reactor is subcritical prior to reactor startup, the hot shutdown margin shall be at least that shown in Figure TS 3.10-1. Shutdown margin as used here is defined as the amount by which the reactor core would be subcritical at hot shutdown conditions if all control rods were tripped, assuming that the highest worth control rod remained fully withdrawn, and assuming no changes in xenon, boron, or part length rod position.

b. Power Distribution Limits

1. At all times, except during low power physics tests, the hot channel factors defined in the basis must meet the following limits:

A. $F_Q^N(Z)$ Limits:

(i) Westinghouse Electric Corporation Fuel

$F_Q^N(Z) \times 1.03 \times 1.05 \leq (2.22/P) \times K(Z)$ for $P > .5$ 48

$F_Q^N(Z) \times 1.03 \times 1.05 \leq (4.44) \times K(Z)$ for $P \leq .5$

(ii) Exxon Nuclear Company Fuel

$F_Q^N(Z) \times 1.03 \times 1.05 \leq F_Q^T(Ej)/P \times K(Z)$ for $P \geq .5$

$F_Q^N(Z) \times 1.03 \times 1.05 \leq (4.42) \times K(Z)$ for $P \leq .5$

8111190702 811116
PDR ADOCK 05000305
P PDR

B. Reduce reactor power and high neutron flux trip setpoint by 1% for each percent that the measured F_Q^{EQ} exceeds the relationship of 3.10.b.4. Reactor power may subsequently be increased provided that adequate margin is demonstrated by a power distribution map to reasonably assure that the relationship of 3.10.b.4 can be met at the increased power level.

7. The reference equilibrium indicated axial flux difference as a function of power level (called the target flux difference) shall be measured at least once per full power month.

8. The indicated axial flux difference shall be considered outside of the limits of sections 3.10.b.9 through 3.10.b.12 when more than one of the operable excore channels are indicating the axial flux difference to be outside a limit.

9. Except during physics tests, during excore detector calibration and except as modified by 3.10.b.10 through 3.10.b.12 below, the indicated axial flux difference shall be maintained within a ±5% band about the target flux 48
difference.

10. At a power level greater than 90 percent of rated power if the indicated axial flux difference deviates from its target band, the flux difference shall be returned to the target band immediately or reactor power shall be reduced to a level no greater than 90 percent of rated power.

11. At power levels greater than 50 percent and less than or equal to 90 percent of rated power:

A. The indicated axial flux difference may deviate from its ±5% target band for a maximum of one hour (cumulative) in any 24 hour period provided the flux difference does not exceed an envelope bounded by -10 percent and +10 percent from the target axial flux difference at 90% rated power and increasing by -1% and +1% from the target axial flux difference for each 2.7% decrease in rated power below 90% and above 50%. If the cumulative

Proposed Amendment 48
November 23, 1981

time exceeds one hour, then the reactor power shall be reduced immediately to less than or equal to 50% power and the high neutron flux setpoint reduced to less than or equal to 55% of rated power.

B. A power increase to a level greater than 90% of rated power is contingent upon the indicated axial flux difference being within its target band.

12. At a power level no greater than 50% of rated power:

A. The indicated axial flux difference may deviate from its target band.

B. A power increase to a level greater than 50% of rated power is contingent upon the indicated axial flux difference not being outside its target band for more than two hours (cumulative) of the preceding 24 hour period. 48

One half of the time the indicated axial flux difference is out of its target band up to 50% of rated power is to be counted as contributing to the one hour cumulative maximum the flux difference may deviate from its target band at a power level less than or equal to 90% of rated power.

13. Alarms shall normally be used to indicate non-conformance with the flux difference requirement of 3.10.b.10 or the flux difference time requirement of 3.10.b.11.A. If the alarms are temporarily out of service, the axial flux difference shall be logged, and conformance with the limits assessed, every hour for the first 24 hours, and half-hourly thereafter.

c. Quadrant Power Tilt Limits

1. Except for physics tests, whenever the indicated quadrant power tilt ratio exceeds 1.02, one of the following actions shall be taken within two hours:

   A. Eliminate the tilt.

   B. Restrict maximum core power level two percent for every one percent of indicated power tilt ratio exceeding 1.0.

2. If the tilt condition is not eliminated after 24 hours, reduce power to 50 percent or lower.

3. Except for low power physics tests, if the indicated quadrant tilt exceeds 1.09 and there is simultaneous indication of a misaligned rod:

   A. Restrict maximum core power level by 2 percent of rated values for every one percent of indicated power tilt ratio exceeding 1.0.

   B. If the tilt condition is not eliminated within 12 hours, the reactor shall be brought to a minimum load condition ($\leq$30 Mwe).

4. If the indicated quadrant tilt exceeds 1.09 and there is no simultaneous indication of rod misalignment, the reactor shall immediately be brought to a No Load condition ($\leq$ 5% reactor power).

d. Rod Insertion Limits

1. The shutdown rods shall be fully withdrawn when the reactor is critical or approaching criticality.

2. The control banks shall be limited in physical insertion; insertion limit is shown in Figure TS 3.10-3. 48

3. Insertion limit does not apply during physics tests or during periodic exercise of individual rods. However, the shutdown margin indicated in Figure TS 3.10-1 must be maintained except for the low power physics test

Proposed Amendment No. 48
November 23, 1981

to measure control rod worth and shutdown margin. For this test, the reactor may be critical with all but one high worth rod inserted and the part length rods fully withdrawn.

e. Rod Misalignment Limitations

1. When reactor power is greater than or equal to 85% of rating the rod cluster control assembly shall be maintained within $\pm$ 12 steps from their respective banks. If a rod cluster control assembly is misaligned from its bank by more than $\pm$ 12 steps (indicated) when reactor power is greater than or equal to 85%, the rod will be realigned or the core power peaking factors shall be determined within 4 hours, and specification 3.10.b applied. If peaking factors are not determined within 4 hours, the reactor power shall be reduced to less than 85% of rating. 48

2. When reactor power is less than 85% of rating, the rod cluster control assemblies shall be maintained within $\pm$ 24 steps from their respective banks. If a rod cluster control assembly is misaligned from its bank by more than $\pm$ 24 steps (indicated) when reactor power is less than 85%, the rod will be realigned or the core power peaking factors shall be determined within 4 hours, and specification 3.10.b applied. 48

3. And, in addition to 3.10.e.1 and 3.10.e.2 above, if the misaligned rod cluster control assembly is not realigned within 8 hours, the rod shall be declared inoperable. 48

f. Inoperable Rod Position Indicator Channels

1. If a rod position indicator channel is out of service, then:

   A. For operation between 50 percent and 100 percent of rating, the position of the rod cluster control shall be checked indirectly by core instrumentation (excore detector and/or thermocouples and/or movable incore detectors) every shift, or subsequent to rod motion exceeding a total displacement of 24 steps, whichever occurs first.

Proposed Amendment No. 48
November 23, 1981

B. During operation below 50 percent of rating, no special monitoring is required.

2. Not more than one rod position indicator channel per group nor two rod position indicator channels per bank shall be permitted to be inoperable at any time.

3. If a rod cluster control assembly having a rod position indicator channel out of service is found to be misaligned from 3.10.f.1.(A) above, then specification 3.10.e will be applied. 48

g. Inoperable Rod Limitations

1. An inoperable rod is a rod which does not trip or which is declared inoperable under specification 3.10.e or 3.10.h.

BASIS

SHUTDOWN REACTIVITY

Trip shutdown reactivity is provided consistent with plant safety analysis assumptions. To maintain the required trip reactivity, the rod insertion limits of Figure TS 3.10-3 must be observed. In addition, for hot shutdown conditions, 48
the shutdown margin of Figure TS 3.10-1 must be provided for protection against the steamline break accident which requires more shutdown reactivity at end of core life (due to a more negative moderator temperature coefficient at 48
end-of-life boron concentrations).

Rod insertion limits are used to assure adequate trip reactivity, to assure meeting power distribution limits, and to limit the consequences of a hypothetical rod ejection accident. The available control rod reactivity or excess beyond needs, decreases with decreasing boron concentration, because the negative reactivity required to reduce the core power level from full power to zero power is largest when the boron concentration is low.

The exception to the rod insertion limits in Specification 3.10.d.3 is to 48
allow the measurement of the worth of all rods less the worth of the worst case of an assumed stuck rod; that is, the most reactive rod. The measurement would be anticipated as part of the initial startup program and infrequently over the life of the plant, to be associated primarily with determinations of special interest, such as end-of-life cooldown or startup of fuel cycles which deviate from normal equilibrium conditions in terms of fuel loading patterns and anticipated control bank worths. These measurements will augment the normal fuel cycle design calculations and place the knowledge of shutdown capability on a firm experimental as well as analytical basis.

Operation with abnormal rod configuration during low power and zero power testing is permitted because of the brief period of the test and because special precautions are taken during the test.

POWER DISTRIBUTION CONTROL

Criteria

Criteria have been chosen for Condition I and II events as a design basis for fuel performance related to fission gas release, pellet temperature, and cladding mechanical properties. First the peak value of linear power density must not exceed the value assumed in the accident analysis.[1, 3] Second, the minimum DNBR in the core must not be less than 1.30 in normal operation or in short term transients.[2]

In addition to conditions imposed for Condition I and II events, the peak linear power density must not exceed the limiting Kw/ft values which result from the large break loss of coolant accident analysis based on the ECCS acceptance criteria limit of 2200°F. 48

$F_Q^N(Z)$, Height Dependent Nuclear Flux Hot Channel Factor

$F_Q^N(Z)$, Height Dependent Nuclear Flux Hot Channel Factor, is defined as the maximum local neutron flux in the core at core elevation Z divided by the core averaged neutron flux, assuming nominal fuel and rod dimensions. 48

$F_Q^{EQ}(Z)$ is the measured F_Q^N distribution obtained at equilibrium conditions during the target flux determination.

An upper bound envelope for F_Q^N defined by specification 3.10.b.1 has been determined from extensive analyses considering all operating maneuvers consistent with the technical specifications on power distribution control as given in Section 3.10. The results of the loss of coolant accident analyses based on this upper bound envelope indicate that peak clad temperatures remain below the 2200^{o}F limit. 48 48

The $F_Q^N(Z)$ limits of specification 3.10.b.1.A include consideration of enhanced fission gas release at high burnup, off-gassing (release of absorbed gases), and other effects in fuel supplied by Exxon Nuclear Company; this results in an additional penalty in the form of the function $F_Q^T(Ej)$, as shown in Figure TS 3.10-6, which is applied to Exxon fuel. References 7 and 8 discuss these phenomena. 48

When an F_Q^N measurement is taken, both experimental error and manufacturing tolerance must be allowed for. Five percent is the appropriate allowance for a full core map taken with the movable incore detector flux mapping system and three percent is the appropriate allowance for manufacturing tolerance. 48

In specification 3.10.b.1 and 3.10.b.4 F_Q^N is arbitrarily limited for $P \leq 0.5$ (except for low power physics tests). 48

$F_{\Delta H}^N$, Nuclear Enthalpy Rise Hot Channel Factor

$F_{\Delta H}^N$, Nuclear Enthalpy Rise Hot Channel Factor, is defined as the ratio of the integral of linear power along the rod on which minimum DNBR occurs to the average rod power.

It should be noted that $F_{\Delta H}^{N}$ is based on an integral and is used as such in the DNB calculations. Local heat fluxes are obtained by using hot channel and adjacent channel explicit power shapes which take into account variations in horizontal (x-y) power shapes throughout the core. Thus the horizontal power shape at the point of maximum heat flux is not necessarily directly related to $F_{\Delta H}^{N}$.

In the specified limit of $F_{\Delta H}^{N}$ there is an 8% allowance for uncertainties[1] which means that normal operation of the core is expected to result in $F_{\Delta H}^{N} < 1.55/1.08$. The logic behind the larger uncertainty in this case is that (a) normal perturbations in the radial power shape (e.g. rod misalignment) affect $F_{\Delta H}^{N}$, in most cases without necessarily affecting F_{Q}^{N}, (b) the operator has a direct influence on F_{Q}^{N} through movement of rods, and can limit it to the desired value, he has no direct control over $F_{\Delta H}^{N}$ and (c) an error in the predictions for radial power shape, which may be detected during startup physics tests can be compensated for in F_{Q}^{N} by tighter axial control, but compensation for $F_{\Delta H}^{N}$ is less readily available. When a measurement of $F_{\Delta H}^{N}$ is taken, experimental error must be allowed for and 4% is the appropriate allowance.

The use of $F_{\Delta H}^{N}$ in specification 3.10.b.5 is to monitor "upburn" which is defined as an increase in $F_{\Delta H}^{N}$ with exposure. Since this is not to be confused with observed changes in peak power resulting from such phenomena as xenon 48
redistribution, control rod movement, power level changes, or changes in the number of instrumented thimbles recorded, an allowance of 2% is used to account for such changes.

Rod Bow Effects

The $F^N_{\Delta H}$ limits of specification 3.10.b.1 include consideration of fuel rod bow effects. Since the effects of rod bow are dependent on fuel burnup an additional penalty is incorporated in a decrease in the $F^N_{\Delta H}$ limit of 2% for 0-15000 MWD/MTU fuel burnup, 4% for 15000-24000 MWD/MTU fuel burnup, and 6% for greater than 24000 MWD/MTU fuel burnup. These penalties are counter-balanced by credits for increased Reactor Coolant flow and lower core inlet temperature. The Reactor Coolant System flow has been determined to exceed design by greater than 8%. Since the flow channel protective trips are set on a percentage of full flow, significant margin to DNB is provided. One half of the additional flow is taken as a DNB credit to offset 2% of the $F^N_{\Delta H}$ penalty. The existence of 4% additional reactor coolant flow will be verified after each refueling at power prior to exceeding 95% power. If the reactor coolant flow measured per loop averages less than 92560 gpm, the $F^N_{\Delta H}$ limit shall be reduced at the rate of 1% for every 1.8% of reactor coolant design flow (89000 gpm design flow rate) for fuel with greater than 15000 MWD/MTU burnup. Uncertainties in reactor coolant flow have already been accounted for in the flow channel protective trips for design flow. The assumed T inlet for DNB analysis was 540°F while the normal T inlet at 100% power is approximately 532°F. The reduction of maximum allowed T inlet at 100% power to 536°F as addressed in specification 3.10.k provides an additional 2% credit to offset the rod bow penalty. The combination of the penalties and offsets results in a required 2% reduction of allowed $F^N_{\Delta H}$ for high burnup fuel, 24000 MWD/MTU. The permitted relaxation in $F^N_{\Delta H}$ allows radial power shape changes with rod insertion to the insertion limits. 48

Proposed Amendment 48
November 23, 1981

Surveillance

Measurements of the hot channel factors are required as part of startup physics tests, at least each full power month of operation, and whenever abnormal power distribution conditions require a reduction of core power to a level based on measured hot channel factors. The incore map taken following initial loading provides confirmation of the basic nuclear design bases including proper fuel loading patterns. The periodic monthly incore mapping provides additional assurance that the nuclear design bases remain inviolate and identifies operational 48
anomalies which would, otherwise, affect these bases.

For normal operation, it is not necessary to measure these quantities. Instead it has been determined that, provided certain conditions are observed, the hot channel factor limits will be met; these conditions are as follows:

1. Control rods in a single bank move together with no individual rod insertion differing by more than an indicated 12 steps from the bank demand position 48
where reactor power is $\geq$ 85%, or an indicated 24 steps when reactor power is $<$85%.
2. Control rod banks are sequenced with overlapping banks as shown in Figure TS 3.10-3. 48
3. The control bank insertion limits are not violated.
4. Axial power distribution control specifications which are given in terms of flux difference control and control bank insertion limits are observed. Flux difference refers to the difference in signals between the top and bottom halves of two-section excore neutron detectors. The flux difference is a measure of the axial offset which is defined as the difference in normalized power between the top and bottom halves of the core.

Proposed Amendment 48
November 23, 1981

The specifications for axial power distribution control referred to above are designed to minimize the effects of xenon redistribution on the axial power distribution during load-follow maneuvers.[9]

Conformance with specification 3.10.b.9 through 3.10.b.12 ensures the F_Q^N upper bound envelope is not exceeded and xenon distributions will not develop which at a later time would cause greater local power peaking.

At the beginning of cycle, power escalation may proceed without the constraints of section 3.10.b.5 since the startup test program provides adequate surveillance 48
to ensure peaking factor limits. Target flux difference surveillance is initiated after achieving equilibrium conditions for sustained operation.

The target (or reference) value of flux difference is determined as follows. At any time that equilibrium xenon conditions have been established, the indicated flux difference is determined from the nuclear instrumentation. This value, divided by the fraction of full power at which the core was operating is the full power value of the target flux difference. Values for all other core power levels 48
are obtained by multiplying the full power value by the fractional power. Since the indicated equilibrium value was noted, no allowances for excore detector error are necessary and indicated deviations of $\pm$5% flux difference are permitted from the indicated reference value. Figure TS 3.10-5 shows a typical construction of the target flux difference band at BOL and Figure TS 3.10-4 shows the typical variation of the full power value with burnup.

Strict control of the flux difference (and rod position) is not as necessary during part power operation. This is because xenon distribution control at part power is not as significant as the control at full power and allowance has been made in predicting the heat flux peaking factors for less strict control at part power. Strict control of the flux difference is not possible during certain physics tests or during required, periodic, excore calibrations which require larger flux differences than permitted. Therefore, the specifications on power distribution control are not applied during physics tests or excore calibrations; this is acceptable due to the low probability of a significant accident occurring during these operations.

In some instances of rapid plant power reduction automatic rod motion will cause the flux difference to deviate from the target band when the reduced power level is reached. This does not necessarily affect the xenon distribution sufficiently to change the envelope of peaking factors which can be reached on a subsequent return to full power within the target; however, to simplify the specification, a limitation of one hour in any period of 24 hours is placed on operation outside the band. This ensures that the resulting xenon distributions are not significantly different from those resulting from operation within the target band. The instantaneous consequences of being outside the band, provided rod insertion limits are observed, is not worse than a 10% increment in peaking factor for flux difference in the range +10% to -10% from the target flux increasing by $\pm$1% from the target axial flux difference for each 2.7% decrease in rated power below 90% 48
and above 50%. Therefore, while the deviation exists the power level is limited to 90% or lower depending on the indicated flux difference without additional core monitoring. If, for any reason, flux difference is not controlled within the

±5% band for as long a period as one hour, then xenon distributions may be significantly changed and operation at 50% is required to protect against potentially more severe consequences of some accidents unless incore monitoring is initiated. 48

As discussed above, the essence of the procedure is to maintain the xenon distribution in the core as close to the equilibrium full power condition as possible. This is accomplished, without part length rods, by using the boron system to position the full length control rods to produce the required indicated flux difference.

For Condition II events the core is protected from overpower and a minimum DNBR of 1.30 by an automatic protection system. Compliance with the specification is assumed as a precondition for Condition II transients, however, operator error and equipment malfunctions are separately assumed to lead to the cause of the transients considered.

QUADRANT POWER TILT LIMITS

The radial power distribution within the core must satisfy the design values assumed for calculation of power capability. Radial power distributions are measured as part of the startup physics testing and are periodically measured at a monthly or greater frequency. These measurements are taken to assure that the radial power distribution with any quarter core radial power asymmetry conditions are consistent with the assumptions used in power capability analyses.

The quadrant tilt power deviation alarm is used to indicate a sudden or unexpected change from the radial power distribution mentioned above. The two percent tilt alarm setpoint represents a minimum practical value consistent with instrumentation errors and operating procedures. This symmetry level is sufficient to detect significant misalignment of control rods. Misalignment of control rods is considered to be the most likely cause of radial power asymmetry. The requirement for verifying rod position once each shift is imposed to preclude rod misalignment which would cause a tilt condition less than the 2% alarm level. This monitoring is required by Technical Specifications, Section 4.1.

The two hour time interval in specification 3.10.c is considered ample to 48
identify a dropped or misaligned rod. In the event that the tilt condition cannot be eliminated within the two hour time allowance, additional time would be needed to investigate the cause of the tilt condition. The measurements would include a full core physics map utilizing the movable detector system. For a tilt condition $\leq$ 1.09 an additional 22 hours time interval is authorized to accomplish these measurements. However, to assure that the peak core power is maintained below limiting values, a reduction of reactor power of two percent for each one percent of indicated tilt is required. Physics measurements have indicated that the core radial power peaking would not exceed a two-to-one relationship with the indicated tilt from the excore nuclear detector system for the worst rod misalignment. In the event a tilt condition of $\leq$ 1.09 cannot be eliminated after 24 hours, the reactor power level will be reduced to the range required for flux mapping and turbine synchronization.

If tilt ratio greater than 1.09 occurs which is not due to a misaligned rod, the reactor shall be brought to a low power condition for investigation by flux mapping. However, if the tilt condition can be identified as due to rod misalignment, operation can continue at a reduced power (2% for each 1% the tilt ratio exceeds 1.0) for the 8 hour period necessary to correct the rod misalignment.

INOPERABLE ROD POSITION INDICATOR CHANNELS

The rod position indicator channel is sufficiently accurate to detect a rod ± 7.5 inches away from its demand position. If the position indicator channel is not operable, the operator will be fully aware of the inoperability of the channel, and special surveillance of core power tilt indications, using established procedures and relying on excore nuclear detectors, and/or movable incore detectors, will be used to verify power distribution symmetry.

INOPERABLE ROD LIMITATIONS

One inoperable control rod is acceptable provided the potential consequences of accidents are not worse than the cases analyzed in the safety analysis report. A 30 day period is provided for the re-analysis of all accidents sensitive to the changed initial condition.

ROD DROP TIME

The required drop time to dashpot entry is consistent with safety analysis.

DNB PARAMETERS

The DNB related accident analysis assumed as initial conditions that the T inlet was $4^{\circ}F$ above nominal design or T avg was $4^{\circ}F$ above nominal design. The Reactor Coolant System pressure was assumed to be 30 psi below nominal design.

REFERENCES

(1) FSAR Section 4.3

(2) FSAR Section 4.4

(3) FSAR Section 14

(4) (deleted)

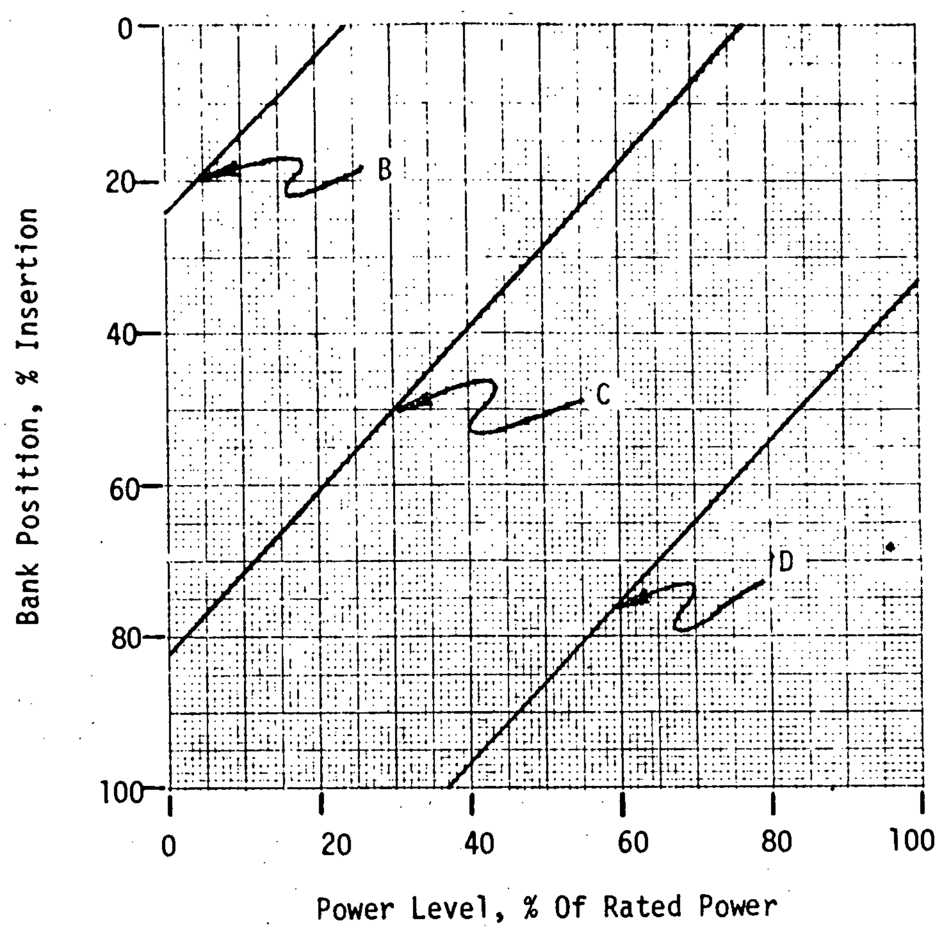
(5) Letter from E. R. Mathews, (WPSC), to D. G. Eisenhut, (NRC), dated January 8, 1980, submitting information on Clad Swelling and Fuel Blockage Models.

(6) Letter from E. R. Mathews, (WPSC), to A. Schwencer, (NRC), dated December 14, 1979, submitting the ECCS Re-analysis properly accounting for the zirconium/water reaction.

(7) George C. Cooke, Philip J. Valentine; "Exposure Sensitivity Study for ENC XN-1 Reload Fuel at Kewaunee Using the ENC-WREM-IIA PWR Evaluation Model, WN-NF-79-72," Exxon Nuclear Company, October, 1979.

(8) Letter from L. C. O'Malley, (Exxon Nuclear Company) to E. D. Novak, (WPSC), providing FQ exposure dependence as a function of rod burnup.

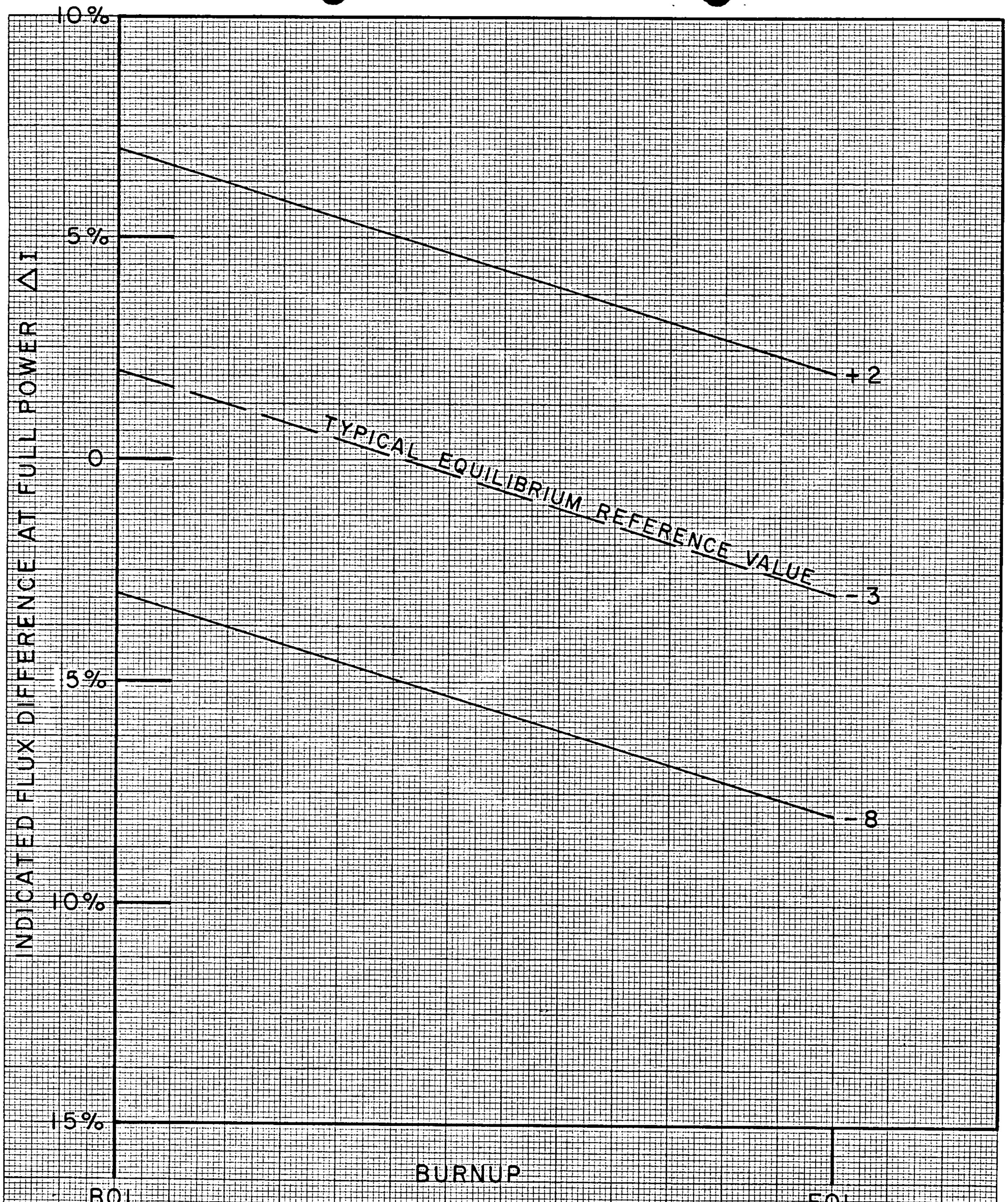
(9) XN-NF-77-57 Exxon Nuclear Power Distribution Control for Pressurized Water Reactor, Phase II, Jan. 1978. 48



CONTROL BANK INSERTION LIMITS

FIGURE TS3.10-3

Proposed Amendment No. 48
November 23, 1981



PERMISSIBLE OPERATING BAND ON INDICATED FLUX DIFFERENCE AS A FUNCTION OF BURNUP (TYPICAL)

Figure TS 3.10-4

46 1512

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

Proposed AMENDMENT Nº 48
November 23, 1981

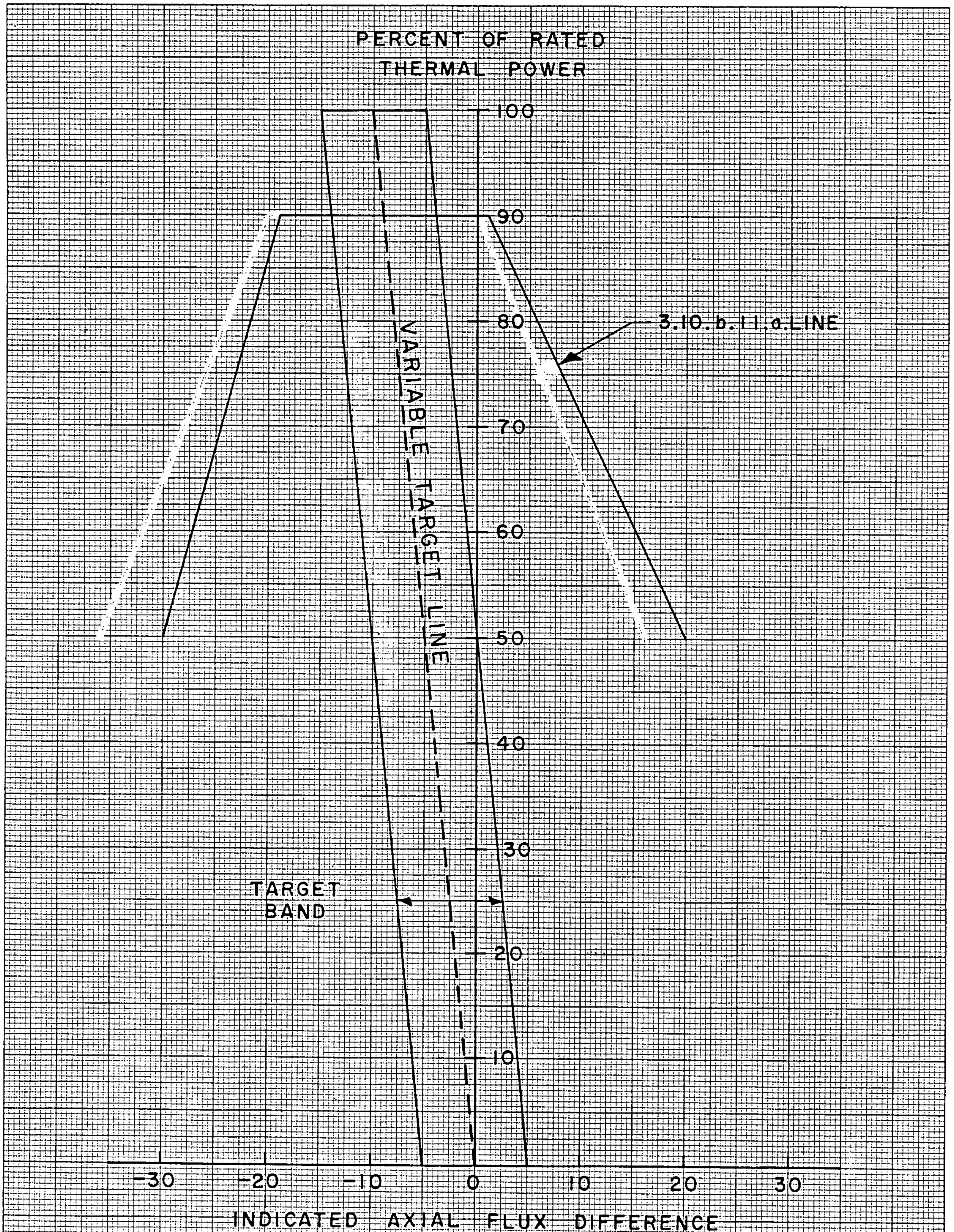
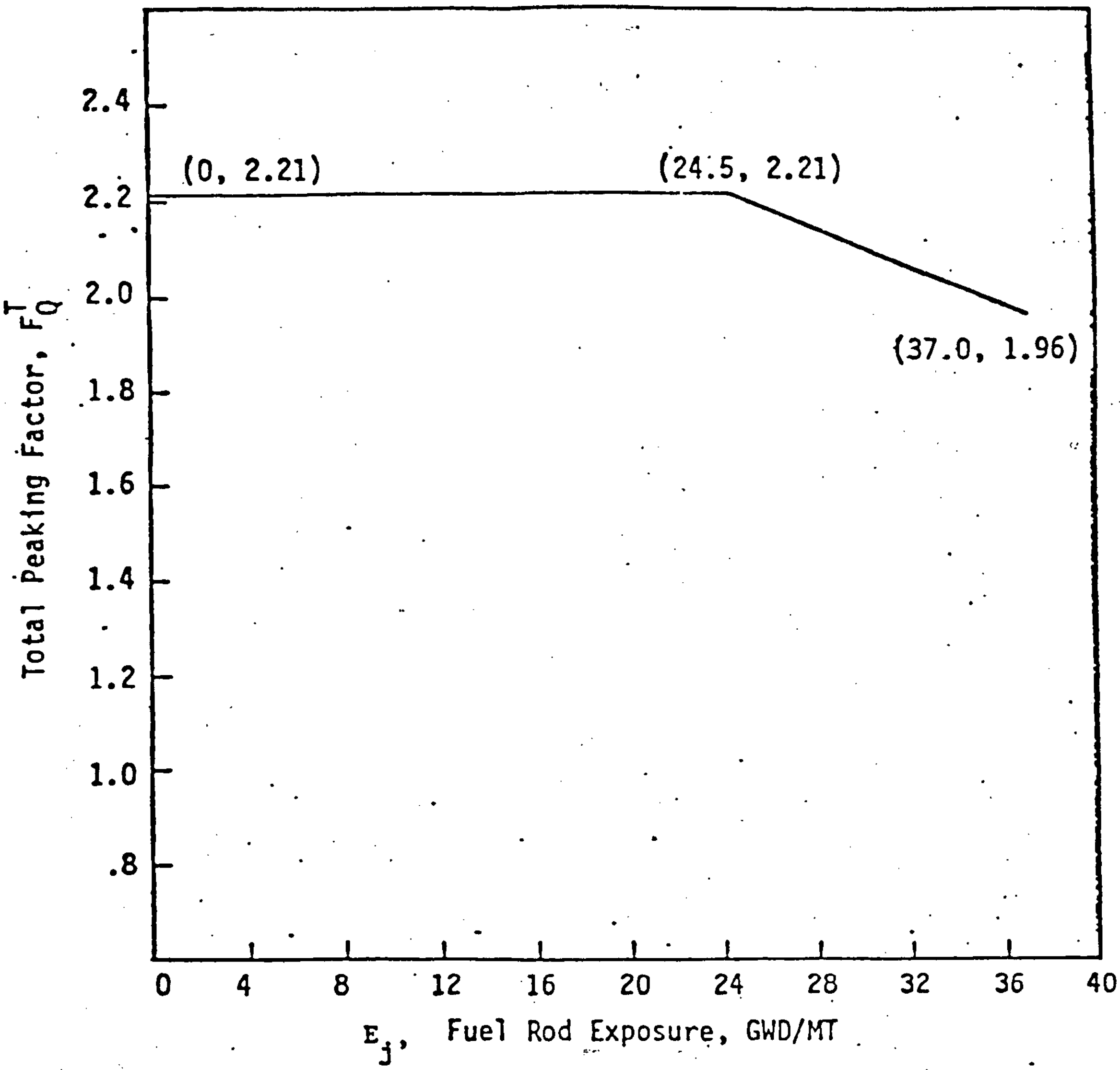


FIGURE TS 3.10-5 TARGET BAND ON INDICATED FLUX DIFFERENCE AS A FUNCTION OF OPERATING POWER LEVEL (TYPICAL)

Proposed AMENDMENT No 48
November 23, 1981

46 1512
K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.



F_Q^T versus Rod Exposure: $F_Q^T(E_j)$

(Reference specification 3.10.b.1.a.(ii))

Figure TS 3.10-6

48

FIGURE TS.3.10-8
REV 34 4/20/79

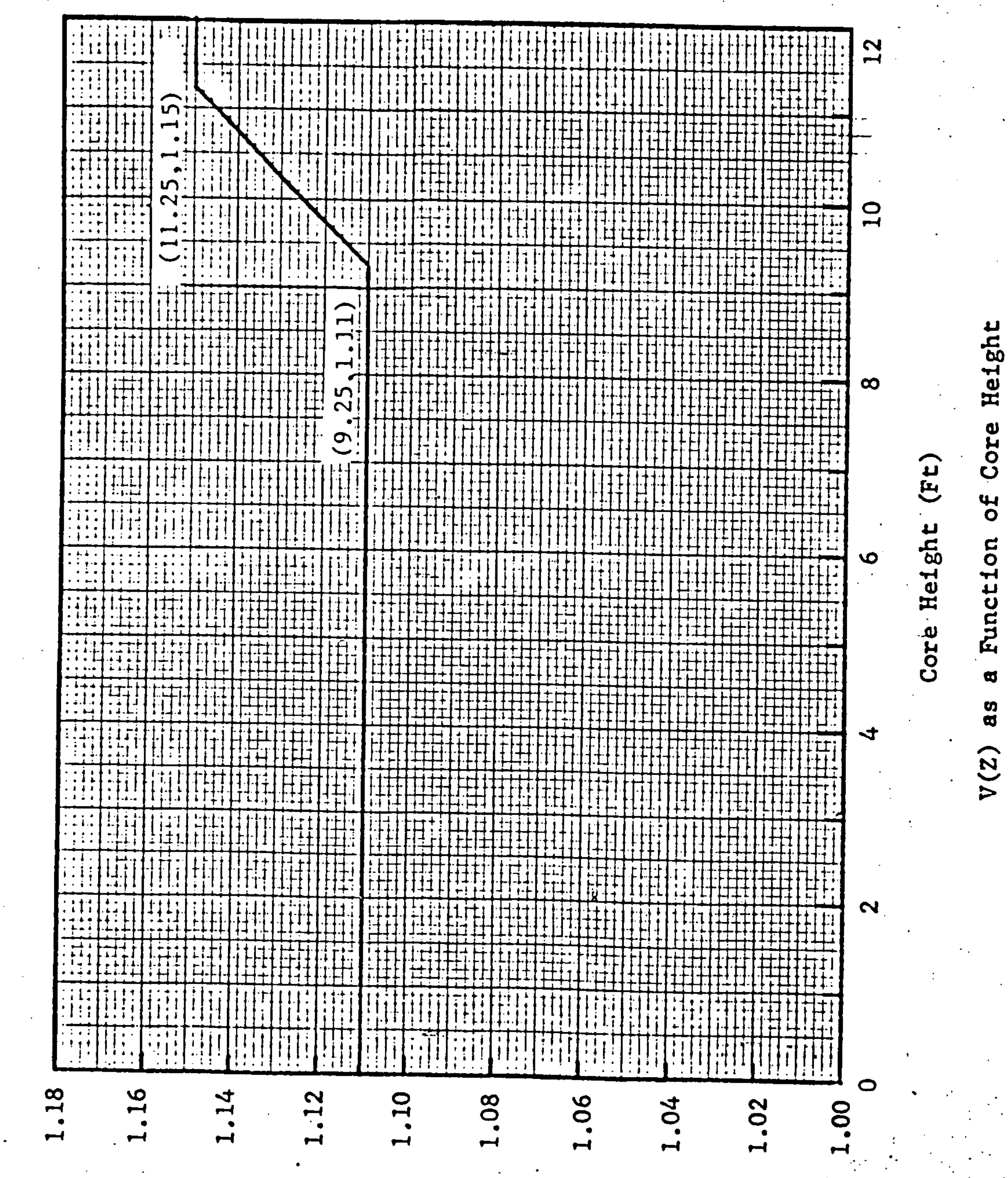


Figure 3.10-7

Proposed Amendment No. 48
November 23, 1981